INSECT PESTS

OF

FARM, GARDEN AND ORCHARD

BY

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To My Wife

PREFACE

The edition of the writer's "Insects Injurious to Staple Crops," first published ten years ago, having been exhausted, the publishers requested a revision. It was found, however, that the advances in economic entomology during the past decade were such that it was necessary to practically rewrite the book. At the time it was first published two other books were projected; one to deal with the insects affecting garden crops, and the other to discuss those affecting fruits. Pressure of regular work prevented the author from completing the manuscript for these works and in 1907 Dr. Chittenden issued his excellent book on "Insects Injurious to Vegetables," so that there seemed to be no immediate demand for another volume on that subject. At the same time two other well-known entomologists were working upon books which would cover fruit insects, so that the writer abandoned the field to them. Subsequently, the work of one of these friends was cut short by his sudden death, and the other abandoned the task, at least for the present.

Under these circumstances, it seemed that there was a distinct place for a book to cover all the insects affecting the crops of farm, garden and orchard, and having leisure to devote to it, the author developed the work in its present form.

It has been the author's effort to discuss all of the more important insects of farm, garden and orchard at sufficient length to give a clear idea of their life histories and habits, and also the best means of control, so that the book may be used as a reference work both by the student of economic entomology and by the practical farmer, gardener, or fruit-grower. Insects of minor

or local importance have been purposely omitted. The insects of practically all of the leading crops are considered, except the citrous fruits. With these the author is unfamiliar, but it is hoped to add a chapter upon them by a competent authority in a subsequent edition. In general, the discussion of insects and their control as given is based upon conditions east of the Rockies, and practically no consideration has been given to the conditions of the Pacific Coast or of the irrigated country of the far West.

The author is well aware that there are doubtless many errors of fact or of wrong emphasis in these pages. Such must necessarily be the case in a work the greater part of which must be compiled. All of the leading authorities on the subjects discussed have been consulted and the writer has endeavored to present their evidence fairly, with such interpretation as his personal knowledge made possible. He will be greatly indebted to those who will aid him in securing the accuracy of the work by reporting any errors or by suggesting improvements in it, as it is hoped to revise the pages from time to time so that they may serve as a reliable reference work upon our insect pests of the farm, the garden, and the orchard.

On the following pages are given the sources from which the illustrations have been secured, but the author wishes to express his special appreciation of the very large number of figures which were furnished him by Dr. L. O. Howard, Chief of the Bureau of Entomology, and Mr. J. A. Arnold, Chief of the Division of Publications, of the United States Department of Agriculture, either as electrotypes or original drawings or photographs, and to Ginn & Company of Boston for the loan of numerous electrotypes made for an Elementary Entomology by Prof. C. F. Jackson and the writer, now being published by them.

E. Dwight Sanderson.

West Virginia University,
Morgantown.

SOURCES OF ILLUSTRATIONS

The author wishes to express his very sincere appreciation of the courtesy extended him by those friends mentioned below who have furnished or loaned him electrotypes, photographs or drawings, thus making possible the ample illustration of this volume.

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INSECT PESTS

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CHAPTER I

THE INJURY TO CROPS BY INSECT PESTS

EVER since the locust plagues in the time of the Pharaohs history is replete with accounts of insect scourges and the enormous losses they have caused the agriculturists of all ages. However, instead of diminishing with the advancement of agricultural methods, injurious insects have undoubtedly become both more numerous and more destructive in modern times. "In no country in the world do insects impose a heavier tax on farm products than in the United States. The losses resulting from the depredations of insects on all the plant products of the soil, both in their growing and in their stored state, together with those on live stock, exceed the entire expenditures of the National Government, including the pension roll and the maintenance of the Army and the Navy."* "Very careful estimates, based on crop reports and actual insect damage over a series of years, show that the loss due to insect pests of farm products, including fruits and live stock, now reaches the almost inconceivable total of $1,000,000,000, annually."† The above quotations from Mr. C. L. Marlatt, Assistant Chief of the Bureau of Entomology,

* C. L. Marlatt, Yearbook U. S. Department of Agriculture, 1904, p. 461.
† C. L. Marlatt, Journal of Economic Entomology, IV, 109.

United States Department of Agriculture, may appear to the reader either ludicrous or startling, according to whether he be more or less informed concerning the important role which insects play in our agricultural economy, which in turn forms the warp of American prosperity.

A brief résumé of the records of damage done by insect pests, of the cost of fighting them, and of the estimates which form the basis of the above statement, will make it the more convincing.

Growing Cereals.—Probably no other insect does so widespread damage as the Hessian fly, attacking our chief staple, wheat, as well as rye and barley. One-tenth of the whole crop, valued at $50,000,000 to $70,000,000, is generally conceded to be destroyed by this pest every year. In certain sections the loss often amounts to from 30 to 50 per cent, and in 1900 was estimated at fully $100,000,000 (Marlatt, l.c.). The southern grain louse or "green bug" caused a loss estimated at from $5,000,000 to $10,000,000 in Texas, Oklahoma and Kansas in 1907, and every year there is a considerable shrinkage of the wheat crop due to the work of various species of plant-lice whose injury doubtless amounts to 2 or 3 per cent of the crop, worth $15,000,000 to $20,000,000.

The corn crop of the United States was worth $1,720,000,000 in 1909. One of the worst pests of this crop in the Mississippi Valley is the chinch-bug. Several years ago Professor F. M. Webster estimated the loss from this insect since 1850 at $330,000,000, and at present it probably destroys at least 2 per cent of the corn crop every year, worth over $30,000,000, and in many years the loss is much more. The western corn root-worm and the corn root-aphis which work unnoticed on the roots of the corn throughout the same territory cause an equal loss. The corn ear-worm often destroys from 5 to 10 per cent of the crop in the South, and throughout the Corn Belt it undoubtedly decreases the crop by 2 or 3 per cent.

The total value of cereal crops in the United States in 1909 was practically $3,000,000,000, which was undoubtedly decreased

by 10 per cent due to the ravages of insect pests, which thus taxed our grain growers some $300,000,000.

Hay and Forage Crops.—A host of small insects attack our grasses and forage crops, many of them being so small that they are unnoticed, though their aggregate injury is something enormous. Of the larger pests of grasses and forage plants the army worms are among the best known and have often caused a loss of over half a million dollars to a single State in one season. Grasshoppers of various species are also always more or less injurious and often become a serious menace. Probably the most serious injury, however, is done by subterranean larvæ such as the cutworms, wireworms, white grubs, and webworms, which breed in sod land, and by the hordes of little leaf-hoppers which are always prevalent, but whose injury often passes unnoticed. Ten per cent of the hay crop was worth $65,000,000 in 1909, and this is a fair estimate of the damage done to hay and forage crops by their insect enemies.

Cotton.—The cotton plant has a number of injurious insect enemies, of which the boll weevil, bollworm, and leafworm are the most injurious. In 1904 the writer made a statistical study of the decrease in the cotton crop of Texas due to the boll weevil, and showed that it was then costing that State $25,000,000 per annum.* This estimate has been confirmed by independent investigations made by Mr. W. D. Hunter of the U. S. Bureau of Entomology, and although the loss in Texas is not so serious at present, the weevil has spread eastward into Alabama, so that its total injury remains practically the same, and has undoubtedly been a large factor in the higher price of cotton in recent years. The bollworm is most injurious in the southwestern cotton-producing States, where it causes a loss of from 5 to 60 per cent of the crop. The total damage to cotton by the bollworm is approximately $20,000,000 per annum and not infrequently exceeds that amount. In 1880 the United States

* E. D. Sanderson, The Boll Weevil and the Cotton Crop of Texas. (Bulletin Dept. of Agriculture, Insurance, Statistics and History, Austin, Texas 1905, p. 28, 7 maps.)

Entomological Commission made an investigation of the cotton worm and valued its ravages at $30,000,000, but with the extensive use of Paris green and arsenical poisons its injury has been greatly reduced and now amounts to from $5,000,000 to $10,000,000 annually. Various minor pests of the cotton plant inflict a considerable amount of local injury and with the above pests damage the crop at least 10 per cent, worth $85,000,000 in 1909.

Tobacco.—Tobacco is attacked by insects, which form one of the chief "bugbears" of tobacco growing, at all stages of its existence. Ten per cent of the crop, worth $10,000,000, is certainly destroyed by them every year.

Truck Crops.—Truck crops are peculiarly susceptible to insect attacks, and their control forms one of the chief items in the cost of production. It is safe to say that truck crops suffer from insect ravages fully twice as much as do the staples, or 20 per cent of their total value. Statistics are not available for the present value of truck crops, but they were probably worth $300,000,000 in 1909, making the insect tax for the trucker fully $60,000,000.

Fruits.—Fruit trees are also much more seriously injured by insects than are the staple crops, and their control involves a large expense to the fruit-grower. Where it is not combated, the codling moth, or apple worm, would cause a loss of from 30 to 50 per cent of the crop, and where it is controlled by spraying a considerable expense is involved. The loss and cost of treatment for this pest alone amount to $20,000,000 for the United States, and were it not for the fact that it is now largely controlled in the principal fruit-growing sections, the loss would be double or treble this sum. The loss due to the San José scale is difficult to estimate, but it is well known that it has destroyed millions of trees and that in the principal fruit regions where this pest is prevalent it is necessary to treat the trees annually at a cost of from 10 to 25 cents per tree, so that $10,000,000 a year would be a very conservative estimate of its annual cost. Both deciduous and citrous fruits have a host of insect pests,

always present and doing more or less damage and occasionally becoming so abundant as to threaten the life of the trees or their crops. Twenty per cent of the value of our fruit products, worth at least $30,000,000, is certainly destroyed by insect pests every year.

Forest Insects.—Only those who have had opportunity to observe the ravages of insects in timber and in timber products can appreciate the enormous losses which they occasion. Probably no one is better informed upon this matter than Dr. A. D. Hopkins, in charge of the Forest Insect Investigations of the U. S. Bureau of Entomology, who has made a life study of these pests in all parts of the country. In a recent circular he states * that "the amount of insect-killed and damaged timber left in the woods, plus the reduction in value of that utilized, to be charged to insects is not far from an equivalent of 10 per cent of the value of the annual output of forest products of all kinds, in the rough. The total value of the forest products of the United States in 1907 is given as $1,280,000,000; the losses from insect depredations would therefore represent an annual loss in cash value of more than $100,000,000." To this should be added a similar loss to farm woodlots, which may be estimated at an additional $10,000,000. The insect injury to the shade trees of city streets, parks, and estates should also be mentioned, for such pests as the gypsy moth, the elm leaf-beetle, tussock moths, etc., are not only causing enormous losses and large expense for their control, but they are often destroying the values of real estate and through killing the trees are destroying the scenic value of property and changing the esthetic environment in a manner which it will require many decades to remedy, if the previous conditions can ever be even partially reproduced. The State Forester of Massachusetts has recently shown that the New England States and the Federal Government have spent fully $7,000,000 in fighting the gypsy and brown-tail moths in New England, and at the present time the New England States, the Federal Government, municipalities and private individuals are spending fully $1,000,000 per annum

* A. D. Hopkins, Circular 129, Bureau of Entomology, U. S. Dept. Agr.

in this warfare for the preservation of their shade and forest trees.

Live Stock. Insect pests, including the ticks and mites, are almost as important as enemies of live stock as of crops. The principal drawback to cattle raising in the South is the Texas fever, transmitted by the cattle tick, which has been charged by the officials of the Bureau of Animal Industry with a loss of $100,000,000 annually. The ox-warble, which causes the "grubby" hides of cattle, causes a loss estimated at from $10,000,000 to $35,000,000 per year due to the depreciated value of the hides and the lessened quantity and poorer quality of the beef of affected animals. The screw-worm fly is a constant annoyance to cattle and source of loss on the range, and numerous biting and parasitic flies cause a considerable loss to the grower of live stock, both through actual damage and through the annoyance preventing growth and production. The sheep scab, sheep tick, the sheep bot—causing "staggers" or "grub-in-the-head"—horn-fly, buffalo-fly, black-fly, and numerous species of lice which affect all of the domestic animals, are among the pests which must be combated by the stockman. In 1909 the live stock products were worth $3,000,000,000, and it is estimated that fully 10 per cent of this amount was lost through injury from insects.

Stored Products. Even after the crops have been gathered and garnered, and indeed after they and animal products have been manufactured, they are constantly subject to the attacks of numerous "weevils," "moths," and other insect pests of stored products. Every housewife and every merchant knows that only through constant surveillance can they prevent these ravages. Mills, tobacco warehouses, storage houses, and vessels, must be frequently cleaned and often must be fumigated to prevent the increase of insect pests peculiar to them. It is estimated that at least 5 per cent of the cereal crops are destroyed by insects while in storage, which would mean a loss of $150,000,000, and in many cases the loss to corn, particularly in the South, is much greater. The total loss due to insects in stored goods of all kinds is impossible to estimate, but would fall not far short of $200,000,000.

With this brief survey of the losses due to insect pests, we may summarize them in a table which will show that the total is based upon conservative estimates.

ANNUAL VALUES OF FARM PRODUCTS AND LOSSES CHARGEABLE TO INSECT PESTS *

Product.	Values.	Percentage of Loss.	Amount of Loss.
Cereals	$3,000,000,000	10	$300,000,000
Hay and forage	665,000,000	10	66,500,000
Cotton	850,000,000	10	85,000,000
Tobacco	100,000,000	10	10,000,000
Truck crops	† 300,000,000	20	150,000,000
Sugars	95,000,000	10	9,500,000
Fruits	† 150,000,000	20	30,000,000
Farm forests	110,000,000	10	11,000,000
Miscellaneous crops	† 100,000,000	10	10,000,000
Animal products	3,000,000,000	10	300,000,000
Total	$8,370,000,000		$972,000,000
Natural forests and forest products			100,000,000
Products in storage			200,000,000
Grand total			$1,272,000,000

* Based upon table of C. L. Marlatt, l.c., modified by statistics of the Secretary of Agriculture, Yearbook U. S. Department of Agriculture for 1909.
† Estimated.

One billion dollars is thus a conservative estimate of the damage done to staple crops, fruits, truck crops, domestic animals, timber and stored products by these apparently insignificant insects.

Yet there is another aspect to the matter. "One man's loss is another man's gain" is never more true than as regards these losses occasioned by insects; for, through widespread injury by them, prices rise, while if these injuries did not occur and correspondingly large crops were placed upon the market, prices must surely fall. These estimates of losses due to insects are then very largely comparative. Yet, to a large extent, they are still real losses, the same as are those occasioned by fire and storm; for

though a small crop may bring better prices, it is usually at the expense of individuals or communities which have sustained exceptionally heavy losses. Were these losses evenly distributed among all those producing a given crop, there would be no real hardship to them; but such is by no means the case.

All this, then, goes to emphasize the fact that the successful farmer—as the successful man in any other trade or profession—is the one who is able to overcome obstacles which, though possibly ruining his neighbor, are making a good market for his special crop; for these insect pests can be largely overcome. The millennium will doubtless come before the farmer will be able to stop fighting them, but a large part of the damage by them can be prevented at a cost which renders it profitable. Rational methods of general farm practice with the proper use of apparatus and insecticides, even such as are now known, and in which improvements are being constantly made, if intelligently used by American farmers, would save to them the larger part of this enormous loss.

CHAPTER II

BENEFICIAL INSECTS, PREDACEOUS AND PARASITIC

Ladybird-beetles

After his strawberries have been ruined by the strawberry weevil, the garden truck by cutworms, the wheat despoiled by the Hessian fly, the melon-patch fallen a prey to plant-lice, and the fruit crop has been a failure on account of the codling moth, plum curculio, and San José scale, it is scarcely surprising that the farmer does as one of my acquaintances did and "orders the hands to kill everything that crawls."

But such would be entirely too heroic a measure, and if strictly adhered to the remedy would be as bad as the disease, for it would mean not only useless labor, but the destruction of the most effective means whereby insect pests are held in check. We pride ourselves—and justly—that with our spray pumps and deadly sprays many crops can be effectually protected; but were it not for those other insects which feed upon these injurious forms, what an enormous, and, in some instances, almost futile task it would be!

Among these beneficial insects the little ladybird-beetles of the family *Coccinellidæ* are entitled to be in the first rank. Almost all the beetles and larvæ feed upon plant-lice and scale insects. Of such value are those feeding upon scale insects that not many years ago several Australian species were imported into California that they might prey upon the San José and other scales. One of these was eminently successful and almost completely destroyed the cottony cushion-scale.

Of those feeding upon plant-lice, one of the most common is the Nine-spotted Ladybird (*Coccinella novemnotata*). This

beetle is about one-fourth of an inch long, with black head and body. The wing-covers are orange-yellow marked with nine black spots—four on each side and one on the central suture. The larva has been fancied to resemble a miniature alligator; it is nearly twice as long as wide, almost black, marked with bluish and orange spots, and has long legs, which carry it around quite rapidly. The beetles hibernate during the winter and come forth in the spring and lay their eggs wherever the young will be able to find food when they hatch. When the larva has satisfied its ravenous appetite and become full grown it fastens itself to a leaf or twig,—seemingly by its tail, if such

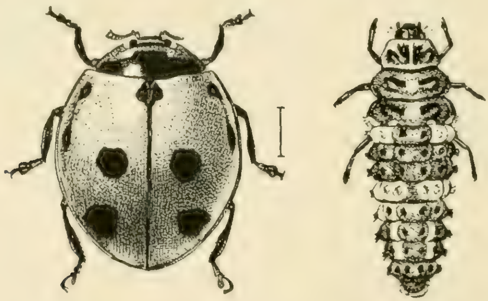


FIG. 1.—The nine-spotted ladybird (*Coccinella novemnotata*), and its larva enlarged. (After Chittenden, U. S. Dept. Agr.)

a term might be allowed,—transforms to the pupa, and in a week or ten days the adult beetle emerges from the pupal skin. This life-cycle is repeated several times during the summer season, before the fall brood enters winter quarters.

Another very common form among plant-lice on garden truck is the little *Adalia bipunctata*, or Two-spotted Ladybird. It is slightly smaller than the preceding, and with only one black spot on each wing-cover (Fig. 2).

Several other species in the genus *Hippodamia* are very useful, and among them the Convergent Ladybird (*Hippodamia convergens*) is one of the best known. Its name is received from two white dashes on the black thorax, which converge posteriorly. The thorax has also a white margin, and there are

thirteen black dots on its orange wing-covers. These larvæ and beetles are very common among the plant-lice on melon-vines, and are an important factor in their extermination. They

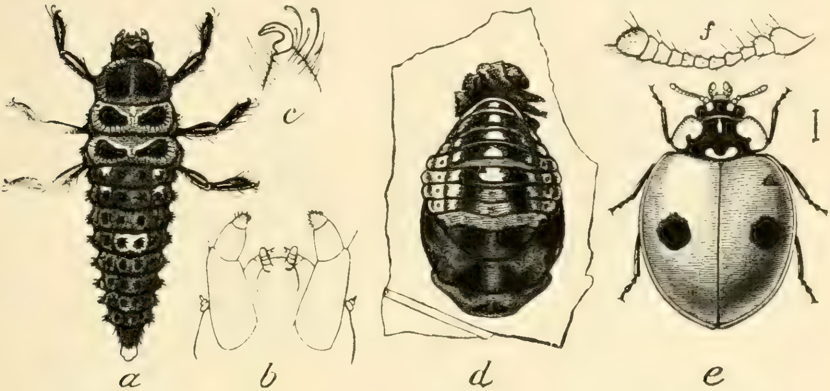


FIG. 2.—The two-spotted ladybird (*Adalia bipunctata*): *a*, larva; *b*, mouth-parts of same; *c*, claw of same; *d*, pupa; *e*, adult; *f*, antenna of same; all enlarged. (After Marlatt, U. S. Dept. Agr.)

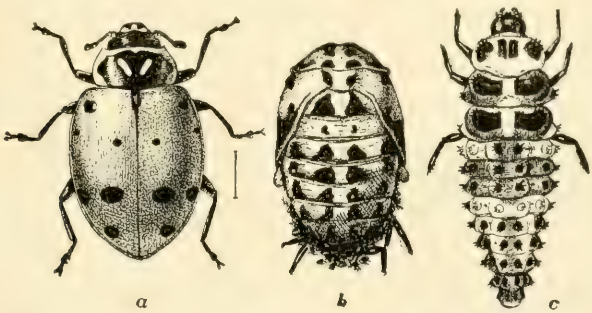


FIG. 3.—The convergent ladybird (*Hippodamia convergens*): *a*, adult; *b*, pupa; *c*, larva; enlarged. (After Chittenden, U. S. Dept. Agr.)

have also been noted for eating the black peach aphis and many other plant-lice.

A form which is often very abundant among plant-lice on corn is the Spotted Ladybird (*Megilla maculata*). The head, thorax, and wing-covers are a dark pink, with two black spots on the

thorax and ten on the wing-covers. Such numbers of these little fellows have frequently been found huddled together under the rubbish at the base of some tree in a last year's cornfield that they might be taken up by the handful without difficulty.

FIG. 4.—The spotted ladybird (*Megilla maculata*): *a*, larva; *b*, pupa; *c*, adult; enlarged. (After Chittenden, U. S. Dept. Agr.)

Many other species feed upon plant-lice, but the above are the most common, and all bear a resemblance to one another, being generally orange or red with black spots, and of a characteristic round or oval form, flattened below, so that the legs may be drawn in under the wing-covers.

FIG. 5.—The twice-stabbed ladybird (*Chilocorus bivulnerus*). *a*, adult; *b*, larva; enlarged. (After Riley.)

Those ladybirds which feed upon scales are much smaller and are black, though sometimes spotted with red or orange.

As far as known, there is no way in which these useful allies may be encouraged or increased in numbers, but it is trusted that the above may give such a brief view of their habits that fewer may be killed through ignorance concerning their true worth.

Syrphus-flies

Besides the little beetles described above there is a family of flies, the *Syrphidæ*, many of whose larvæ feed upon plant-lice. This family is a very large one, and thus the habits of its different members vary considerably. One of them, the drone-fly, so closely resembles a honey-bee as to be almost indistinguishable from it. The larva of this fly (*Eristalis tenax*) is one of the common rat-tailed maggots which are found in putrid matter. It is thought that the old "bugonia" superstition of the ancients that bees came from maggots in dead aninmals, etc., was due to the confusion of this fly with honey-bee.

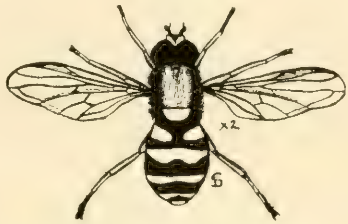


FIG. 6.—*Syrphus ribesii*; enlarged.

In another group of the family, the adult flies of which also quite closely resemble bees, the larvæ are parasitic in the nests of honey- and bumble-bees, feeding upon their larvæ.

But the larvæ of possibly the most typical portion of the family, embracing the genus *Syrphus* and its near allies, are entirely predaceous upon plant-lice. Rarely can a colony of plant-lice be found without some of these little enemies hard after them.

The adult syrphus-fly is a very striking insect, with its dark green metallic thorax, and abdomen variously banded with yellow and black. The female fly lays her eggs upon some plant bearing plant-lice. The larvæ which hatch from these are elongate, flattened maggots, about one-half an inch long, with hardly a trace of a head, but with four small hooks, which serve as jaws, projecting from the more pointed end of the body. These maggots are often of a light-green color, and so like the color of the plants as to render them most difficult to recognize. The young larvæ at once commence crawling over the plant in search of aphids, and as soon as they come in contact with one it

is firmly clasped by the small hooklets until the juices are sucked from its body. In this manner very large numbers are destroyed, a single maggot of the American Syrphus-fly (*Syrphus americanus*) having been observed to eat twenty-five apple plant-lice (*Aphis pomi*) in as many minutes. When the larva is ready to pupate it attaches itself to a leaf, and the larval skin dries up and forms a case or puparium inside of which the pupa remains until it transforms to the adult fly.

Though most of these larvæ feed upon plant-lice upon the leaves, one of them, the Root-louse Syrphus-fly (*Pipiza radicans*), lives entirely underground during that stage, and feeds upon

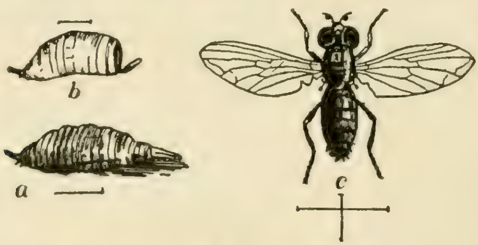


FIG. 7.—The root-louse syrphus-fly (*Pipiza radicans*). *a*, maggot; *b*, puparium; *c*, fly. (After Riley.)

the root-lice of the apple and the grape. None of this family are injurious, and as a large portion of them are so beneficial as to frequently destroy whole broods of plant-lice, they should not be disturbed in their good work if possible to avoid it.

The Ground-beetles

If, as you scrape away the loose chips at the base of a tree in your door-yard, turn over an old log in the woodland, or pick up a fallen fence-rail, you will scrutinize the inhabitants under these shelters, a number of shining black beetles varying in length from one-fourth to 1½ inches will usually be noticed. If the city reader be not so fortunate as to be familiar with or have access to these hiding-places, he may find large numbers of the beetles under any electric arc light during the warm summer evenings; for there they are having a sumptuous banquet upon the small

flies and moths attracted by the glare. They are rarely seen at large during the day, as they are almost exclusively nocturnal insects, and from their habit of remaining almost entirely in or on the ground they are usually known as "Ground-beetles." As might therefore be inferred, they are exceedingly valuable to the farmer by destroying large numbers of noxious insects which pass a part or all of their existence in the soil. Besides the glossy black forms which are most commonly seen, many are brilliantly marked with gold, green, purple, and iridescent tints.

The Fiery Ground-beetle (*Calosoma calidum*), so called on

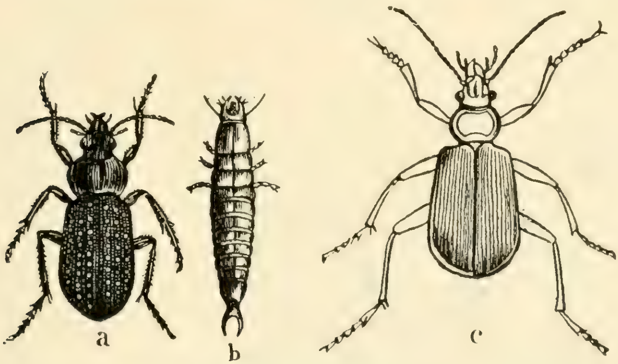


FIG. 8.—The fiery ground-beetle (*Calosoma calidum*). *a*, beetle; *b*, larva; *c*, "the searcher" (*Calosoma scrutator*). (After Riley.)

account of the wing-covers being dotted with bright gold, has many times been of great assistance in helping to rid a corn-field of cutworms. The larvæ of this insect are about one inch in length, of a dark brown color, with the skin of a hard, horny texture like that of the beetle. They have strong, prominent jaws, and at the posterior end of the body is a forked appendage looking much like another pair of jaws. It is not only surprising that these larvæ will eat so large a number of cutworms, as they have frequently been known to do, but that they will dare to attack such a formidable creature fully three or four times as large as themselves, but their assault is sharp and vigorous, and a single larva has often been seen to kill and eat

several full-grown cutworms in a short time. Many instances of the good work of this beetle are on record, among which one by the late Professor J. A. Lintner may be cited, where he found them eating large numbers of the corn-crambus—sometimes locally known as the corn bud-worm. Another somewhat larger beetle, called by Professor J. H. Comstock "the Searcher" (*Calosoma scrutator*), and in fact one of the largest of the family, is a brilliant metallic green, bordered with a dark purplish-blue, and has the good quality of having a very particular appetite, causing it to kill large numbers of caterpillars, but eating only part of each.

While in the earth as pupæ large numbers of the Colorado potato-beetles are destroyed by members of this family, and one species, *Lebia grandis*, which is peculiar in that the wing-covers are somewhat abbreviated, thus leaving the tip of the abdomen exposed, has been noticed on the plants eating the eggs and young larvæ of this old potato pest.

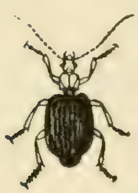


FIG. 9.—*Lebia grandis*. (After Riley.)

Another valuable species is one called by Dr. Riley the Murky Ground-beetle (*Harpalus caliginosus*). Its larva is of considerable assistance to fruit-growers by eating

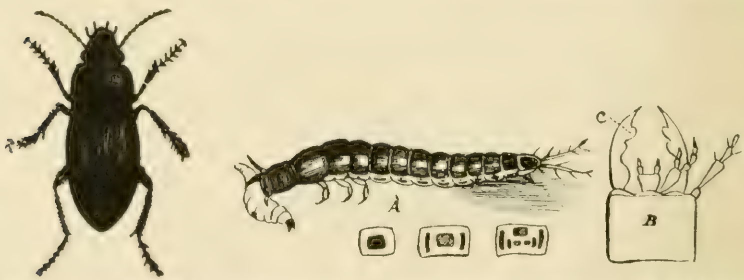


FIG. 10.—The murky ground-beetle (*Harpalus caliginosus*): adult at left; *a*, larva; *b*, head of same; *c*, mandible. (After Riley.)

large numbers of curculio larvæ, which it secures from the plums after they have fallen to the earth. From a glance at its formidable jaws, Fig. 10, *b–c*, it is easy to conjecture the fate of many a curculio grub.

Thus here again are found some "bugs" that are friends and not foes, worthy of all the protection that can be afforded them, and well repaying such careful observation of their habits as may be bestowed upon them.

Insect Parasites

Though large numbers of injurious insects are annually destroyed by those which are purely predaceous upon them, many more succumb to those minute forms which live parasitically within them. A few of these parasites belong to the order *Diptera*, or true flies, but most of them are classed in the order *Hymenoptera*, in which order are also included the saw-flies, ants, wasps, and bees.

Of the half-dozen families of hymenopterous parasites one of the largest and most beneficial is that of the Ichneumon-flies. The illustrations will best show the form and structure of these insects, which the casual observer will hardly be able to distinguish from other families of the group. But it will be noticed that the fine veins of the wings vary considerably in the different parasites figured, and it is by these that the entomologist is enabled to separate the different groups and often to identify the species at a glance. Both this and the following family are peculiar in having an exceedingly long ovipositor or egg-tube, of which they make a very good use. It is with this extensile tube that the female deftly punctures the skin of some unsuspecting caterpillar, and under it inserts her eggs. In a few days there hatch from these a host of young maggots which feed upon the juices and

FIG. 11.—Maggots of *Pimpla inquisitor*, a parasitic Ichneumon-fly, feeding on a caterpillar which had spun its cocoon and was ready of pupate.

tissues of the caterpillar, but are seemingly careful to avoid injuring any of its vital organs, for as soon as the caterpillar reaches its full growth it changes to a pupa, apparently unaffected. When the maggots have reached their full size each spins up a small silken cocoon inside the pupa, entirely filling up its now dead shell, and instead of a beautiful moth appearing in the spring, a horde of small flies are seen to emerge from a round hole in the side of the pupa, or cocoon.

Thus large numbers of such pests as the apple-tree tent-caterpillar (*Clisiocampa americana*), bagworms (*Thyridopteryx ephemeræformis*), caterpillars of the swallow-tailed butterflies which feed upon parsley, carrots, etc., and a host of others, are consumed by members of this family.

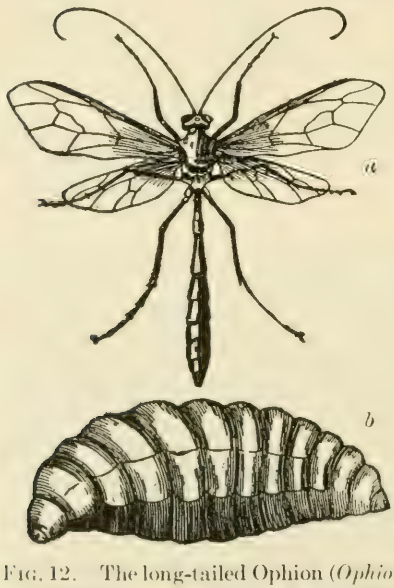


FIG. 12. The long-tailed Ophion (*Ophion macrurum*). *a*, adult; *b*, maggot; enlarged. (After Riley.)

Those belonging to the genus *Ophion* are partial to the large American silkworms which produce some of our largest and most beautiful moths, and difficulty is frequently experienced in rearing a desired number of moths on account of the large per cent of cocoons parasitized.

The species of the family *Braconidæ* are very similar to those of the preceding one, and contain some equally beneficial insects, feeding as they do upon such pests as the codling moth, webworms, plum-curculio grubs, plant-lice, etc. Some of the more common forms of this family belong to the genus *Microgaster*, and their small white cocoons may frequently be seen almost covering one of our large tomato- or tobacco-worms (see page 234), the pupæ of which are often known as "horn-blowers." Many mistake

these cocoons for the eggs of the worms, and therefore destroy some of their best friends. Though some thus spin their cocoons on the outside of the host, others remain inside of the parasitized insect until the adult fly emerges. Thus dead plant-lice may often be found with a large round hole in the abdomen—the only evidence of where one of these parasites has emerged. For this reason dry, shrunken plant-lice should never be destroyed.

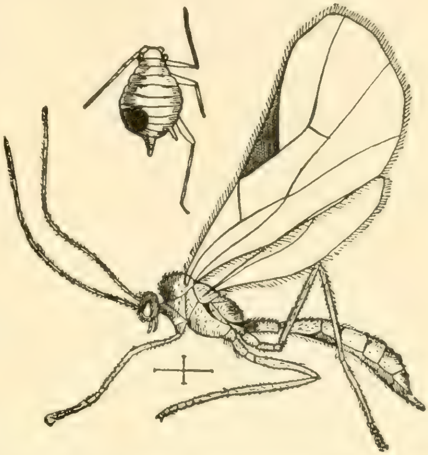


FIG. 13.—A plant-louse parasite (*Aphidius avenaphis*), showing above the parasitized louse from which it has issued. (Copied from J. B. Smith.)

The Chalcis-flies, which comprise another closely related family, are exceedingly minute insects, sometimes not over one one-hundredth of an inch long. They are generally of a metallic black color, and the usual veins of the wings are almost entirely absent. Many of these flies are parasitic upon plant-lice, while a large number of their larvæ live and mature in the eggs of other insects.

Very similar to the chalcis-flies in their habits of infesting plant-lice and insect eggs are some even smaller insects—in fact the smallest known, the largest being rarely over one-twenty-fifth and the smallest only six- or seven- one-thousandths of an inch in length—with a correspondingly tremendous and unpronounceable name, known to science as the *Proctotrypidæ*.

During the last half century the American farmer has been compelled to contend with an increasing number of insect pests, which now and then have become veritable scourges. Every now and then we hear of communities assembling for prayer and fasting to appease the Almighty, whose wrath has hurled a new insect plague against them, but such a procedure is by no means as com-

mon as formerly, and little reflection will show that these scourges are entirely due to natural causes. In fact they are very largely brought about by man himself. Some of these pests are due to the fact that in trying to subdue nature by clearing and cultivating the land, man has deprived the insects of their natural food plants. They must, therefore, needs feed upon that which is substituted by him, and as it is less abundant than the former wild vegetation, the number of insects and the injury they inflict are more apparent.

By far the larger number of our worst pests, however, are those which come to us from foreign shores. Foreign insects are constantly being imported in one way or another, sometimes being already established pests in other lands and sometimes only becoming so under their new surroundings. These are even more injurious than those native, for whereas many of our native birds, insects, and diseases constantly prey upon native insects and thus keep their numbers in check, the enemies of imported pests rarely accompany them, and they thus increase at an alarming rate and do enormous damage before they are attacked by the natural enemies of similar native pests. It is in the case of these imported pests that the value of parasitic and predaceous insects is most apparent. In an effort to make use of them to fight the gypsy and brown-tail moths in New England, the U. S. Bureau of Entomology has for several years been importing large numbers of the parasites and predaceous enemies of these pests and liberating them in affected regions, thus carrying on a practical experiment on a large scale which may show the importance of these parasites in combating imported pests.

Even with our native pests, however, we have frequent examples of the value of parasitic and predaceous enemies. Thus the southern grain louse, or "green bug," was soon brought under control by the myriads of little parasites which preyed upon it (see page 155), and these were artificially transported for some distance and liberated in large numbers. Though these efforts at the distribution of this parasite may be open to some question as to their effectiveness, other parasites have been successfully

distributed, and there can be no question that before long we shall come to better understand how we may make use of these valuable allies, and some day we may be able to duplicate the apparent miracle by which Dame Nature sweeps away an insect plague in a few days with the aid of these apparently insignificant parasites.

CHAPTER III

STRUCTURE AND DEVELOPMENT OF INSECTS

THE more experience the farmer has with insect pests, the more he comes to realize that if he would successfully combat them, he must have a certain amount of necessary knowledge concerning their structure and growth.

In general, the *artificial* means which may be effectually used to combat an insect pest will depend more or less upon the anatomical structure of the insect, while control by general methods of *culture* will depend upon a knowledge of the peculiarities of its life-history. The value of a proper understanding of these important factors in insect control is therefore apparent.

General Structure of an Insect

The body of an insect is composed of three separate parts, the head, thorax, and abdomen (Fig. 14), each of which is composed of several rings or segments. To the head are attached the jointed antennæ, or feelers, the compound eyes, and the mouth-parts, which are described below. Each of the three segments of the thorax bears a pair of legs, and adult insects usually possess one or two pairs of wings upon the last two segments of the thorax. The abdomen is composed of nine or ten segments, but bears no appendages save the ovipositor of the females of certain orders.

FIG. 14.—Honey-bee, showing the three principal regions of the body of an insect:—*h*, head; *th*, thorax; *abd*, abdomen.

Harvest-mites, or "daddy-long-legs," sow-bugs, thousand-legged worms, and similar vermin are often popularly called insects, but all of them can readily be distinguished from true insects by their possessing more than six legs, the harvest-mites and spiders having eight and the others many more.

How Insects Grow

With rare exceptions insects hatch from eggs laid by the adult females. Upon hatching they are but little larger than the eggs, and often bear but little resemblance to their parents. Thus the young caterpillar would never be recognized as the immature stage of the butterfly by one unfamiliar with its transformations. Grasshoppers and some other insects, however, upon hatching from the egg bear a marked resemblance to the adult form, except that they lack wings.

Complete Metamorphosis.—When the caterpillar hatches from the egg it at once commences to feed and grows very rapidly, but before long an obstacle to further growth arises. Unlike higher animals, insects possess no internal skeleton or framework for the organs of the body, but the outer skin becomes hardened and to it the muscles and ligaments are attached. This hardening of the skin is best seen in the horny wing-covers of the beetles, and is due to the secretion of a hard substance called chitin. This chitin is secreted by all parts of the skin in greater or less degree, and thus forms a sort of shell for the whole body. Though this hardening is not so apparent in larvae as in adult insects, it is always present, and it is for this reason that when the young caterpillar has made a certain growth it is forced to shed its skin, which refuses to expand further, in order to develop more fully. Thus the skins of insects are shed several times (see Fig. 15, *b*),—usually five or six, but sometimes as many as twenty, this process being known as *molting*. During its life as a caterpillar, which is called the *larval stage*, and during which it is called a *larva*, it is an elongate, worm-like creature, with six short, jointed legs on the three thoracic segments, a pair of fleshy false legs or pro-legs on the last abdominal segment, and probably

several pairs of pro-legs between these and the true legs. No traces of wings can be seen, but the body is often covered with hairs, spines, or warty tubercles.

With the next molt the insect changes in appearance most radically, becoming a *pupa*, or *chrysalis*, as this stage is termed

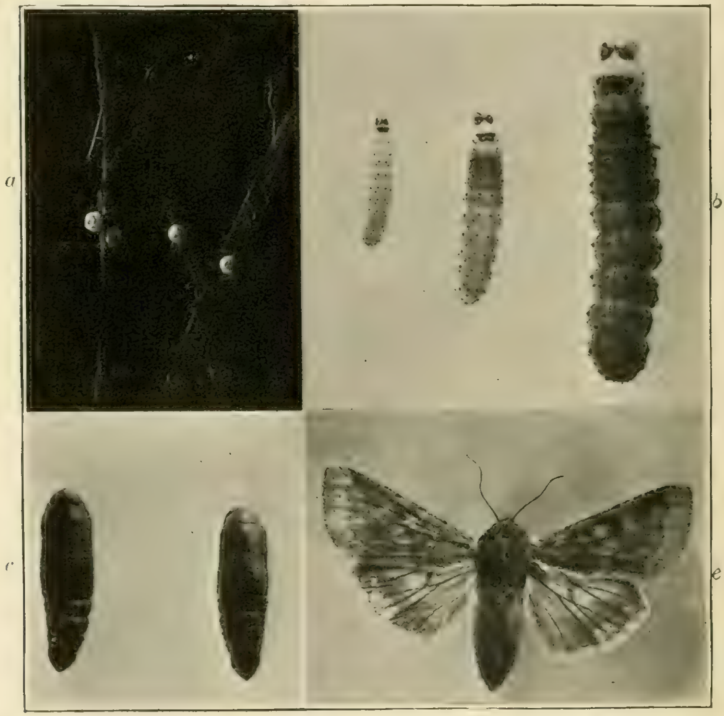


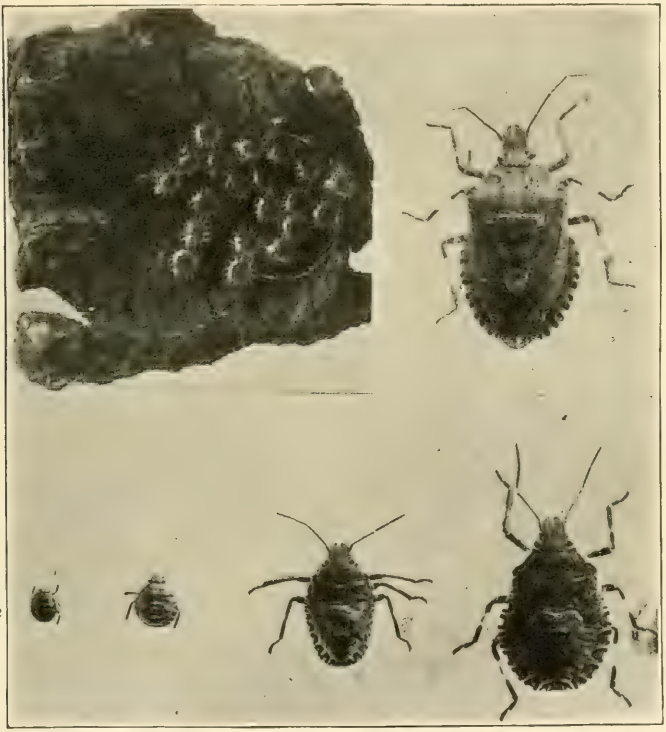
Fig. 15.—Complete metamorphosis. The different stages of the corn earworm (*Heliothis obsoleta* Fab.): *a*, eggs on corn-silk; *b*, the first three larval stages; *c*, pupa from below; *d*, same from above; *e*, adult moth—all enlarged; *b*, about twice natural size.

for butterflies. During the pupal stage the insect remains dormant either in a small cell slightly under the surface of the earth, or in a silken cocoon spun by the caterpillar, or merely attached to the food-plant by a strand of silk or the cast larval skin. In many of the Diptera, the order including flies, mosquitoes, gnats, etc.,—however, the last larval skin is not shed,

but hardens and forms a case—called a puparium—within which the pupal stage is passed.

The typical pupa (Fig. 15, *c*, *d*) of a butterfly or moth resembles neither the adult insect nor the larva, is of a more or less oval shape, with the wings and antennæ tightly folded at

a



b

c

Fig. 16.—Incomplete metamorphosis of a bug (*Brachymena 4-pustulata*): *a*, eggs; *b*, adult bug; *c*, different stages of young bugs or nymphs.

the sides, the legs drawn up snugly together under them, and the head and mouth-parts bent upon the breast, or sternum, though all of these parts are not always recognizable, the legs and mouth-parts being sometimes lacking. Gradually the adult insect develops, and at last the pupal skin is broken open and the airy butterfly emerges to enjoy a short life and perpetuate the species.

Such a series of transformations is that commonly found among butterflies and moths (Lepidoptera), beetles (Coleoptera), flies (Diptera), and bees (Hymenoptera), and is known as a *complete metamorphosis*. All of these insects normally pass through four stages, of egg, larva, pupa, and adult.

Incomplete Metamorphosis.—In contrast to this mode of development is that of the grasshoppers (Orthoptera), bugs (Hemiptera), and some other insects. As already stated, these are much like the adult upon emerging from the egg. With each molt they become larger and small wing-like pads gradually appear on the sides of the thorax. There is no dormant or pupal stage, the adult insect differing from the previous stages in having fully developed wings, being larger, and often by an accompanying change of markings. The immature stages of such insects are called *nymphs*, and this development an *incomplete metamorphosis*, having but three stages, of egg, nymph, and adult (Fig. 16).

The time occupied by the complete life-cycle of an insect varies from a week or ten days for the plant-lice to thirteen or seventeen years for some cicadas, and is entirely dependent upon the habit of the species and the climate. A correct knowledge of the exact time and conditions under which the transformations occur for each individual insect pest is therefore often most essential when seeking means for its control.

How Insects Feed

The material to be used in combating a given insect is largely dependent upon the structure of its mouth-parts. Much Paris green is wasted upon insects unable to eat it and which it will, therefore, never kill.

Insects may be roughly divided into two classes, those which bite and those which suck their food. Among the former are the beetles, grasshoppers, the larvæ of butterflies and moths, and the larvæ of saw-flies; and among the latter are butterflies, flies, bees, and bugs, while the larvæ of most flies and bees do not possess mouth-parts homologous with those of the above.

Biting Mouth-parts.— Mouth-parts typical of those of biting insects are easily seen in the grasshopper (Figs. 17 and 18). In brief, they consist of an upper and a lower lip, between which are two pairs of jaws which work transversely. The upper pair of jaws, or *mandibles* (*md.*), are stout, short, and horny, usually sharpened at the tip, slightly serrated at the margins, and flattened at the base. The lower pair of jaws, or *maxillæ* (*mx.*), are longer, not so strong, and to each of them is attached an accessory lobe, and a jointed

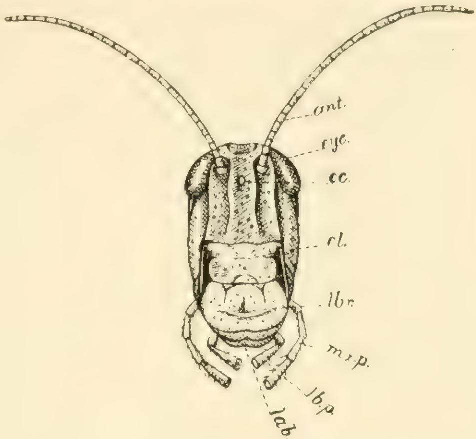


Fig. 17.—Front-view face of grasshopper (*Schiztocerca americana*): *ant.*, antenna; *oc.*, ocellus; *ey.*, eye; *cl.*, clypeus; *lbr.*, labrum, or upper lip; *mx.p.*, maxillary palpus; *lab.p.*, labial palpus; *gal.*, galea, lobe of maxilla; *lab.*, labium, or under lip.

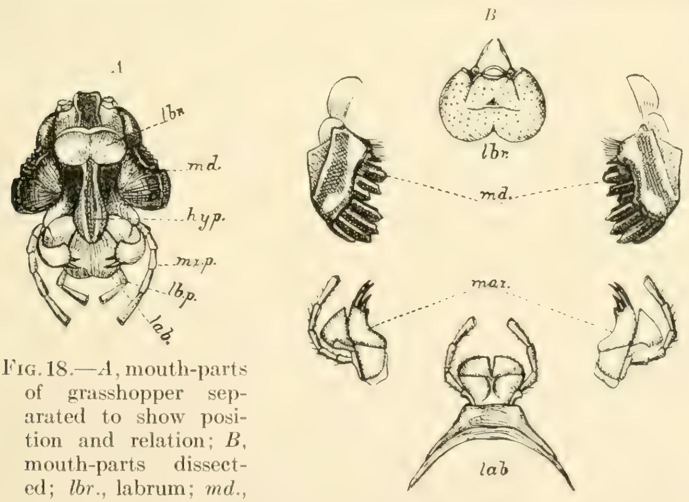


Fig. 18.—*A*, mouth-parts of grasshopper separated to show position and relation; *B*, mouth-parts dissected; *lbr.*, labrum; *md.*, mandible; *hyp.*, hypopharynx or tongue; *mx.p.*, maxillary palpus; *lb. p.*, labial palpus; *lab.*, labium; *max.*, maxillæ.

style called a palpus or feeler. At each side of the lower lip is another palpus, these palpi being sensory organs.

Fig. 19.—Cicada, showing mouth-parts of a bug, a sucking insect: *a*, seen from below, beak or rostrum (*ro. G.*) reposing between forelegs; *b*, head removed: *e*, eye; *lbr.*, labrum; *md.*, mandible-setæ; *mx.*, maxillary setæ; *lab.*, labium.

Sucking Mouth-parts.—In the sucking insects these mouth-parts are prolonged into a tube through which the juices of the food plant —or animal—are sucked. In the plant-lice and other bugs the lower lip is elongated so that it forms a tube, and the maxillæ and mandibles consist of long hair-like bristles, or setæ, enclosed within this tube (Fig. 20). The tip of this beak is rested upon the surface of a leaf into which the setæ are thrust, lacerating the tissue, and by a pumping process of the mouth the juices are sucked up through the beak. The structure of the mouth-parts of the various orders of sucking insects varies considerably, but all agree in that they suck up the food in a liquid state. Any application of a poisonous spray to the surface of foliage will be of no avail against them, though sure death to most biting insects which chew the leaves. Sucking insects must therefore be killed by other means.

How Insects Breathe

Along the side of a caterpillar or larva, on one thoracic segment and on each abdominal segment except the last, is a small oval spot, in the centre of which is a slit closed by two mem-

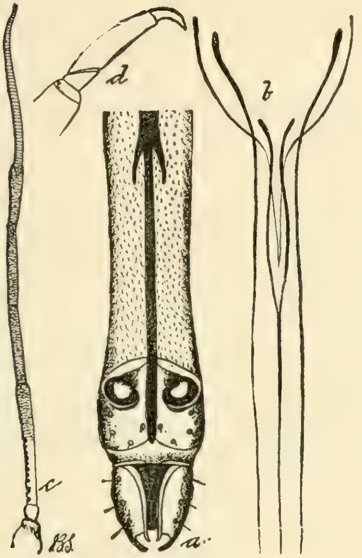


FIG. 20.—Mouth-parts of a plant-louse: *a*, the jointed beak; *b*, the lancets, much enlarged; *c*, antenna; *d*, foot. (After J. B. Smith.)

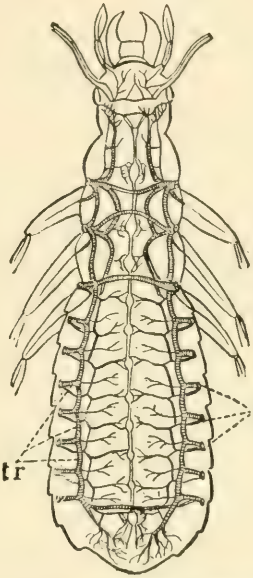


FIG. 21.—Diagram of tracheal or breathing system of an insect: *sp.*, spiracles; *tr.*, trachea. (After Kolbe.)

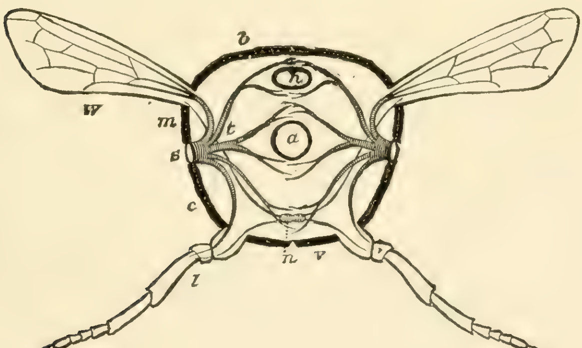


FIG. 22.—Ideal section through an insect: *a*, alimentary canal; *h*, heart; *n*, nerve cord; *s*, spiracle; *t*, tracheal tubes; *l*, legs; *w*, wings. (From Riverside Natural History.)

branous lips. These apertures are called spiracles or stigmata (Fig. 21 *sp.*), and are the openings of the respiratory system. Similar openings are to be found in all insects, though not so easily seen in the adults. Connecting these spiracles is a pair of tubes on each side of the body, throughout its length, from which branch off smaller tubes to all of its organs and tissues. Fresh

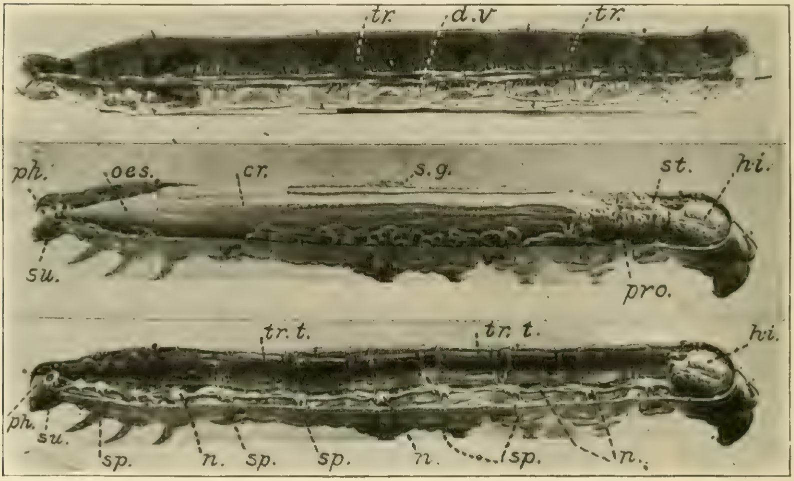


Fig. 23.—Internal anatomy of silk-worm, from photo of Azoux Model: *A*, upper or dorsal bodywall seen from within; *B*, the back of the silk-worm removed, showing alimentary canal; *C*, alimentary canal removed, showing nervous system and tracheal trunks; *tr.*, trachea; *d.v.*, dorsal vessel or heart; *ph.*, pharynx or mouth; *su.*, supra-oesophageal ganglion; *sp.sp.*, spiracles or breathing pores; *n.*, nerve cord; *tr.t.*, tracheal trunk; *oes.*, oesophagus or throat; *cr.*, crop; *s.g.*, silk gland; *pro.*, proventriculus; *st.*, stomach; *h.i.*, hind intestine.

air is thus inhaled to all parts of the body through these tubes (Fig. 21, *tr*).

The blood of insects does not circulate through any system of tubes as it does in the higher animals. Along the middle of the back, above the alimentary canal, is a long tube popularly called the heart (Fig. 23, *dv*). This heart is composed of a number of chambers, each of which is furnished with side valves for admitting blood from the body-cavity. The blood coming into the heart from the body-cavity is propelled forward toward

the head, where it again flows into the body-cavity. Thus various currents of blood are maintained throughout the body, but other than the heart there is no system of blood-vessels, the blood merely filling the body-cavity around and through the various organs and tissues. Constantly flowing around the respiratory tubes or tracheæ, the blood is quickly and thoroughly purified, though the exact manner in which this is done is not definitely known. The respiratory system has absolutely no connection with the mouth or pharynx (Fig. 23, *ph*), as have the lungs of the higher animals, and if an insect is to be suffocated, it must be done by closing the spiracles. It is in this way that tobacco-dust, lime, pyrethrum, and similar insecticides kill sucking insects, by penetrating the spiracles and choking the tracheal system. Whale-oil soap, kerosene emulsion, and the other "contact" insecticides, or "irritants," also stop up the spiracles and thus cause death, but they may act as "irritants," penetrating the skin and thus killing the insect. When insects are killed by means of a gas such as carbon bisulfide or hydrocyanic acid gas, they are asphyxiated by a substitution of these gases for air, the same as are the higher animals.

Though arsenical poisons are generally used as sprays for biting insects, soft-bodied caterpillars and similar larvæ are often killed by the use of contact insecticides, which affect them the same as sucking insects.

The reader will observe that, almost without exception, the remedies advised for different insect pests in the following pages are determined by some peculiarity, either of structure or development, of the insect to be combated.

CHAPTER IV

FARM METHODS FOR THE CONTROL OF INSECTS

THE old adage "an ounce of prevention is worth a pound of cure," is never more true than in the control of insect pests, for in almost all cases their successful control is by prevention before the injury has become acute, rather than by destruction after the injury is noticeable. Even insecticides must be applied so that they will kill the insect before it has done serious damage, for after damage is apparent it is too late to prevent the injury, so that the use of insecticides for the protection of crops must be of a preventive nature. In the control of insects affecting the staple crops which are grown over immense areas with a small profit per acre, it is evidently impracticable to use insecticides and mechanical methods which are used in the orchard and garden. For the control of staple crop insects we are compelled to rely largely on general methods of farm management, which may be carried out in connection with the farm operations at small cost, and which will fatally interfere with the development of the insect to be controlled. To do this intelligently involves an understanding of the life-history of the insect, revealing the time at which it is most vulnerable and the reason for the method of control advised. The importance of such a knowledge of the life histories and habits of insects to be controlled by farm methods will become apparent in the following chapters.

Though the insects affecting staple crops are more largely controlled by farm methods, those of the garden and orchard may be much reduced by the intelligent application of the same principles, and he who adapts his methods so as to prevent insect attack will be much more successful than if he depends upon artificial means for their destruction.

Looking Ahead.—In planning the management of their land and crops for the coming season, few farmers consider the effect which any given procedure will have upon the injurious insects with which they may have to contend. A field which has for several years been in wheat, corn, or tobacco, may be sown with some other crop for the sake of soil improvement, but how often is it considered necessary to rotate crops to avoid insect pests? In most cases they are left out of consideration until a crop has been seriously injured and the necessity for a change of methods thus impressed on the owner.

Particularly while crops are young they should be frequently inspected and examined for any evidence of the pests which commonly affect them. Be prepared to attack any pests which may be found upon their first appearance, for many of the most destructive insects increase with amazing rapidity, and when they have become abundant it is too late to prevent the damage.

Crop Rotation.—One of the most important factors in insect control is the rotation of crops in such a manner that the same crop shall not be grown continuously on the same land. In many cases a yearly rotation will be advantageous, while a frequent rotation will always be found beneficial. Many insects feed on only one crop. It is evident, therefore, that if they hibernate in or near the field which it occupied and it is then planted to the same crop the next year, they will be furnished food for their increase, while if the field be planted in a crop not attacked by the insects peculiar to it, they will have to migrate from it, with probably a very considerable mortality as a consequence, for they will radiate in all directions and many will die before finding food, while many more will have been destroyed in the preparation of the old field for the new crop.

The western corn root-worm may be entirely controlled by a rotation so that corn is never grown two successive years on the same land, for the larvæ feed only on the roots of corn, and when it is followed by a small grain, grass, or clover, they are starved out. Injury by the Hessian fly to wheat is also very materially

reduced where a frequent rotation is practised, as is that of the chinch-bug on corn.

Care should be exercised to arrange a rotation in which crops nearly related botanically do not follow each other, for usually the same insects attack them. Thus white grubs, cutworms, and wireworms live normally in grass land, and where it has not been plowed for several years they often become exceedingly abundant. If the sod be then turned under and the land planted to corn these insects will attack the corn, and as there are relatively few plants to the number of insects which were feeding upon the grass, the injury will usually be serious. To avoid this, sod land should be planted in a small grain, buckwheat, potatoes, or some crop not affected by these pests. Similarly, the insects which affect cabbage usually feed on all the cole crops, and turnips, radishes, etc., following cabbage will be liable to injury by the same pests. Clovers, cowpeas, and other leguminous crops become of importance in rotation in this connection, as they are not usually attacked by the insects affecting other crops, and of course are widely used in every good rotation for the purpose of storing nitrogen in the soil through their root tubercles.

Time of Planting. Planting crops so that they may avoid the greatest abundance of their worst insect enemies is often the best method for their protection. Thus late-sown wheat is usually exempt from the attack of the Hessian fly (see page 123) and late-planted corn is much less affected by the stalk-borer (see page 172) than that planted earlier. On the other hand early planting of early-maturing varieties often enables the crop to mature before its pests become most abundant. Thus early planting and early varieties are of the greatest importance in preventing injury by the cotton boll weevil, the cotton bollworm and corn ear-worm. Early cabbage plants seem to be less injured by root-maggots, and early varieties of peas escape the injury of the pea aphis.

Weeds.—Many insects feed upon some common weed in one stage while in another stage they are injurious to a cultivated crop. Thus the flea-beetles feed upon the roots of solanaceous

weeds during the larval stage, while the adults attack all sorts of garden crops. In many cases caterpillars, such as the salt marsh caterpillar, army worms, the white-lined sphinx moth, and grasshoppers multiply upon weeds growing in neglected fields until they overflow and destroy crops. Many insects feed on weeds during the early part of the season or after the crop which they injure is harvested, so that the destruction of these weeds may often considerably shorten their breeding season or increase their mortality. Thus the corn root-aphis lives on the roots of smartweed and other weeds and grasses until corn is available, and cutworms feed on whatever vegetation is found before a crop is planted. In this connection "volunteer" plants should be classed as weeds, as they frequently furnish food for insects in the same way. Thus the cotton boll weevil feeds on volunteer cotton in early spring and the Hessian fly on volunteer wheat in late summer and early fall. Such useless trees as wild cherry and seedling apple trees might also be considered as weeds, as they harbor many of the insect pests of our orchards and should be destroyed as far as possible.

Fertilization and Culture.—Although there is some evidence that under some conditions, kainit, lime and nitrate of soda may have some direct effect on insects, it is probable that their chief importance is to so stimulate the plant that it will not be subject to insect attack or will grow in spite of some injury. It is well known that plants which have been weakened from any cause whatsoever are much more subject to the attacks of insects and diseases, and it is therefore obvious that plants which have had a vigorous growth and which will mature rapidly will much better withstand insect attack. Thorough preparation of the soil before planting, liberal fertilization, and thorough culture are most important in growing a crop in spite of its insect enemies. In many cases liberal fertilization and culture will mature a good crop where under poorer care it would have succumbed to insect injury. In general, land covered with barnyard manure presents more favorable conditions for the hibernation of insects than that fertilized with mineral fertilizers, but unless this is very appreciably

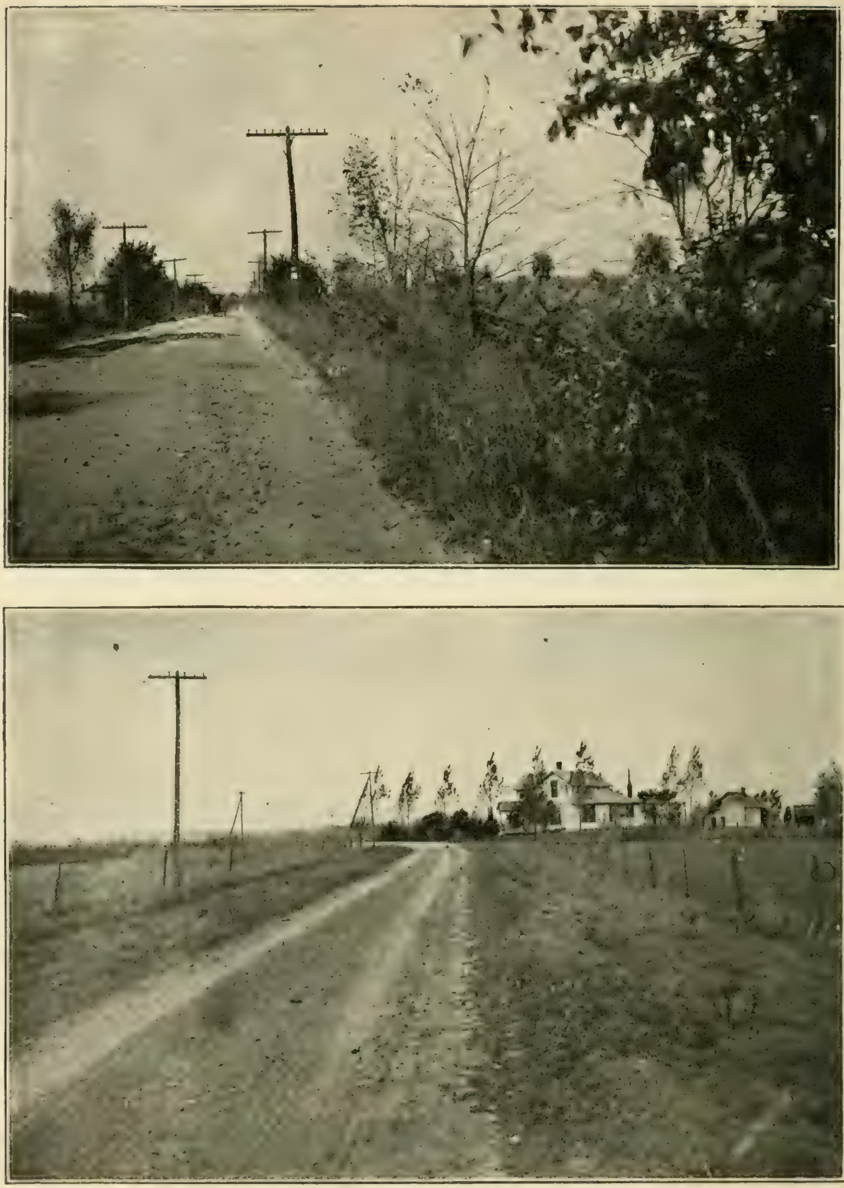


FIG. 24.—Above, a poorly kept roadside with railfence overgrown with brambles, thus affording protection for large numbers of destructive insects during winter. Below, a well kept roadside, offering the least protection possible for destructive insects. (After Webster, U. S. Dept. Agr.), 36

the case, it will usually be preferred to them as far as it is available.

Clean Farming.—After a crop has been harvested there is usually some portion of the plant which is allowed to remain on the land. In this refuse the insects peculiar to the crop often feed and multiply until killing frost and then hibernate over winter, ensuring injury to similar crops on the same land the

FIG. 25.—A field of cabbage stumps in midwinter, affording ideal conditions for the hibernation of cabbage pests.

next year. Thus the wheat jointworm and the corn stalk-borer both winter in the stubble of those crops, and the chinch-bug commonly hibernates in the butts of corn stalks, all of which may be largely controlled by burning the stubble. Possibly the most important means of control of the cotton boll weevil is the destruction of the stalks in the fall as soon as the cotton can be picked, thus preventing the weevils feeding and starving them out before they are ready to hibernate, and removing the shelter for hibernation. Thus all the remnants of a crop such as

stubble, vines, leaves, or stumps, as may be, should be removed from the field as soon after it is harvested as possible. As many insects hibernate in such rubbish, this fact may sometimes be utilized by thoroughly cleaning a field and leaving one or two piles of rubbish in which many of the insects will assemble for hibernation, and which may then be burned or otherwise destroyed. Many cabbage insects hibernate under the old stumps and leaves and will congregate in piles of them. The premises upon which the fence rows are kept free from weeds and grass and the fields are cleaned up and plowed as soon as possible after a crop is removed, usually suffer much less from insect pests than those of more easy-going neighbors.

Burning.—Such cleaning up of stubble and of wild vegetation which furnishes food and shelter for insects may often be accomplished by burning. The burning over of grass land aids greatly in the control of army worms, chinch-bugs, grasshoppers and plant-lice, while the burning of the stubble will largely control the wheat jointworm. Strawberry beds are sometimes burned over in early spring to destroy the eggs of the root-louse, and aphides on small grains may sometimes be killed out on small areas by covering with straw and burning while the plants are small.

Plowing.—Deep plowing and thorough harrowing are the most effective means of ridding the soil of many pests of staple crops.

Late Fall Plowing.—Where the succession of crops permits, plowing in the late fall is most advantageous, as it destroys the insects while hibernating, although for some insects early fall plowing and thorough harrowing during the fall are preferable. Where plowing is not possible, thorough disking is often used for the same purpose, as on alfalfa. As different insects pass the winter in different stages this method does not affect all alike. Some will be destroyed by having the cells in which they have gone to pass the winter broken up, and being unable to construct new cells they will be subjected to undue freezing and thawing and excessive moisture, and will thus be killed by the weather. Cutworms and the corn stalk-borer pass the winter in the soil

as larvæ; the cotton bollworm or corn ear-worm hibernates in the pupal stage; while May beetles and click beetles hibernate as newly transformed beetles; but all of them will be similarly affected by the breaking up of their winter cells, which is the most effective manner of combating them.

Other insects lay their eggs in the ground in the fall which may be buried too deep for the young to emerge, or larvæ or pupæ which normally remain near the surface may be turned under so deeply as to destroy them. Thus grasshopper's eggs are laid in the fall just beneath the surface, and by plowing in late fall or early spring they may be turned under so that but few are able to emerge, which is the best means of combating them. The apple maggot hibernates in the pupal stage just beneath the surface of the soil, and by deep plowing in early spring the puparia may be buried too deeply for the flies to emerge.

Young grasshoppers are often destroyed after they hatch by plowing deep furrows, starting at the outside of the field and plowing in a square, thus forcing them to the centre and catching large numbers of them in the furrows.

Early plowing and thorough harrowing in the spring are of value against cutworms by keeping the ground fallow and thus starving them out before a crop is planted and the same method may be used against other pests with similar habits.

Thorough cultivation in the summer has been found to be of value against many insects, affecting them differently according to their habits. Many which pupate in the soil during the summer are destroyed while making their pupal cells, or these cells are broken and they are thus subject to abnormal moisture and temperature conditions and are thus killed. This has been shown to be the case with the cotton bollworm or corn ear-worm, and is true of the plum curculio, against which thorough cultivation has proved to be one of the most effective means of control in apple orchards. Thorough cultivation is also of importance in breaking up the nests of ants which care for such aphides as the corn root-aphis. Summer fallowing is used to starve out some pests; for example, the clover root-borer may be eradicated by plowing up

infested clover immediately after it is cut and exposing the roots to the sun and wind, which will soon dry them out and thus destroy the food of the larvæ, which will soon perish.

Trap Crops.—Trap crops are those which are planted as a bait or lure to attract the early insects so that they may be destroyed upon them before the crop to be protected is available. Doubtless the reason that trap crops are not more frequently used by the farmer is because their successful use requires more or less of a knowledge of the life history and habits of the pest to be fought. But that is easily acquired and will make the fight against them more interesting and successful.

South of Mason and Dixon's line the harlequin cabbage-bug frequently becomes the most serious pest of cabbage and related plants. When a cabbage patch has become well infested it is an exceedingly difficult matter to prevent injury, for the adult bugs cannot be killed by insecticides which will not injure the plant. If, however, a crop of kale be planted the previous fall, the bugs which hibernate over winter will attack it in the spring, and may then be killed by spraying them with pure kerosene, and the danger to the cabbage crop be thus largely averted.

A few rows of wheat are often planted early in the fall as a trap for the Hessian fly, and as soon as the eggs are deposited they are plowed under deeply and the later planting thus at least partly protected.

One of the most successful examples of averting injury by a trap crop is the use of corn to lure the cotton bollworm and thus prevent its injury to cotton. Corn is the favorite food plant of this pest, which prefers to deposit its eggs on the silk and tassels. By planting a few strips of late-maturing corn through the cotton field, they will come into silk about the time the brood of moths which normally deposit their eggs on cotton are flying and they will lay them on the corn in preference, which should then be cut and fed to stock. In this way by planting strips composed of several rows planted at successive dates, the cotton may be almost entirely protected. Possibly a modification of this method may be applied for the protection of tomatoes or tobacco, though these

crops have never been thus protected from this insect to our knowledge.

Radishes are sometimes used as a trap crop for the root-maggots which affect the roots of cabbages and onions. The same principle is sometimes used in combating forest insects by girdling a tree upon which certain kinds of forest pests will concentrate, and it is then cut and burned.

These examples will suffice to show that very many of the most important insect pests may be largely controlled by simply adapting the general methods of farm management so as to avoid or prevent injury by them. They indicate the importance of a knowledge of the life history of any insect which is to be combated, knowing which, some of the above or similar methods will often suggest themselves as applicable. Such a control of insect life through the practical use of natural agencies epitomizes the scientific method in the art of agriculture; i.e., the most practical and effective and yet simple methods based upon exact knowledge.*

* See F. M. Webster, Farm Practice in the Control of Field Crop Insects, Yearbook U. S. Dept. Agr., 1905, p. 465, and Some Things that the Grower of Cereal and Forage Crops Should Know about Insects, Yearbook U. S. Dept. Agr., 1908, page 367.

CHAPTER V

INSECTICIDES

MATERIALS used for the destruction of insects are commonly called insecticides, and are roughly divisible into four classes:

1. *Poisons*, which kill by being eaten and are usually composed of various forms of arsenic and are therefore often called *arsenicals*.

2. *Contact insecticides*, which kill by either clogging up the spiracles, the openings of the respiratory system, or by entering the trachea, and thus causing suffocation, or by their corrosive action on the skin.

3. *Repellants*, which deter the insect from attacking the plant or animal to which they are applied.

4. *Gases*, which are used for fumigating buildings, stored products and greenhouses where other means are not practicable.

1. Poisons

Poisons are applied to the food of the insect and must be eaten by it to be effective. It is evident, therefore, that they are only effective against biting (mandibulate) insects, or for those which lap up their food from the surface, and that they are of no avail against the true sucking insects, such as the true bugs which suck the juices from beneath the surface of the plant. Poisons are not always, however, the most effective means of combating biting insects, which are sometimes more effectively controlled by contact insecticides or other means.

Nearly all of the stomach poisons are derivatives of arsenic and are therefore termed arsenicals. As they are dangerous to human life they should be kept well labeled, locked up when not in use, and vessels in which they have been used should be carefully cleaned.

1. *Paris green* is a green crystalline powder composed of the aceto-arsenite of copper. When properly made it should contain at least 50 per cent arsenic oxid (As_2O_5), and there should be as little water-soluble arsenic as possible, for the water-soluble arsenic is the cause of the burning of foliage which often results from the use of Paris green. Various State laws require that there be not over 3½ per cent soluble arsenic, but even this amount is often injurious to tender foliage. Paris green is rather a coarse powder and settles readily in water, and is readily washed off by drenching rains. It costs from 25 to 35 cents per pound. It is usually used at a rate of from 3 to 8 ounces to a 50-gallon barrel of water; 5 ounces per barrel is satisfactory for most purposes. In mixing, first stir up in a small vessel with a little water into a paste, which will mix more readily. Add an equal weight of quicklime, or slightly more will do no harm, which will take up any soluble arsenic.

2. *London purple* is a waste product in the manufacture of aniline dyes, and is principally arsenic and lime. It is quite variable in composition and usually contains a much higher, and quite variable, amount of soluble arsenic, so that it is apt to scald the foliage unless thoroughly mixed with fresh stone lime. For this reason it is now used only for rough work, such as poisoning grasshoppers, making poisoned bran mash, etc., and is not to be recommended for general use on fruit trees and garden crops. It usually costs 10 or 12 cents a pound, and is used in the same proportions and in the same way as Paris green.

3. *Arsenate of lead* is usually sold in the form of a white paste, composed of arsenic and lead, the exact chemical composition varying with the process of manufacture. To be of standard grade it should contain at least 12½ per cent of arsenic oxid and not over ¾ per cent water-soluble arsenic oxid (As_2O_5), and not over 50 per cent water. Owing to the small amount of soluble arsenic it may be used in much larger quantities than other arsenicals and on tender foliage which others will injure. From 2 to 8 pounds per 50-gallon barrel of water are used, 2 or 3 pounds per barrel being commonly used for most of the

pests of the orchard and garden. Arsenate of lead remains in suspension rather better than Paris green and is exceedingly adhesive, remaining on the foliage for two or three months. Arsenate of lead is made from arsenate of soda and acetate of lead or nitrate of lead, and may be made by the user if desired, but owing to the varying composition of these chemicals when purchased on the open market and the fact that the manufactured article can now be purchased in quantity practically as cheap as it can be made, its home manufacture is not recommended, and is now but rarely practiced. The market price of arsenate of lead has varied widely, owing to strong competition, but usually sells at from 8 to 10 cents per pound in 100-pound kegs, and at 20 cents for single-pound packages.

Arsenate of lead is now made in a powdered form for dusting on crops where spraying is impracticable or unsatisfactory. Most of that manufactured in powdered form is crystalline and will not mix as readily with water as the paste, and is therefore not recommended for use with water. One manufacturer, however, is producing an amorphous powder, which is bolted like flour, and which mixes readily with water, and may be used exactly the same as the paste, of course using approximately only half as much weight for the same effectiveness, as half of the paste is water.

4. *Arsenite of lead* is a compound very similar to the arsenate, which is made from sodium arsenite, but it contains less arsenic and usually much more soluble arsenic, for which reason its use has not proven satisfactory, and is rarely sold by reliable dealers.

Used in Water.—The above arsenicals are generally diluted with water and applied as a spray, which is usually much the most efficient method. Where Bordeaux mixture or lime-sulfur is to be sprayed on fruit trees or garden crops for the control of fungous diseases, the arsenical may be added to them at the same rate as to water. The combination of arsenicals with other common fungicides is not usually possible without danger of serious injury to the foliage.

Used as Dust.—Under some circumstances the arsenicals are more readily applied in the dust form. Dusting may be done

most effectively by the use of a powder-gun, which consists of a rotating fan which drives the poison from a reservoir through a tube by which it may be directed to the desired point. The powder-guns most commonly used are carried by a man, though larger machines carried on a wagon are in use for orchard work. Paris green is usually diluted with 10 to 20 parts of flour, ground gypsum, or preferably air-slaked lime, though some prefer to use it undiluted when machines are used which control the amount of the application. Dusting should be done while the dew is on the foliage in early morning, except on such plants as have a rough or adhesive foliage. Paris green is frequently used as a dust upon potatoes, cabbage and other garden crops, as well as for dusting weeds and grass for grasshoppers, army worms, etc. Powdered arsenate of lead has recently been shown to be an effective remedy for the cotton boll weevil (see page 272), and is used pure. Its use in dry form will doubtless be found more practicable on other crops than has that of Paris green.

5. *Arsenite of lime* is a home-made arsenical, very much cheaper than those previously mentioned, and giving very satisfactory results for certain purposes. It is not as adhesive as arsenate of lead, and as it sometimes burns foliage has been largely discarded for orchard spraying. It is, however, very satisfactory for potatoes and other low-growing crops, especially when added to Bordeaux mixture, which sticks it to the foliage, and it may be used to good advantage for fighting grasshoppers and leaf-eating caterpillars when it is desired to poison considerable areas of weeds or waste grass. The so-called Kedzie formula is the most satisfactory, as the soda hastens the complete combination of the arsenic, and the resulting solution is in a clear liquid form which can be readily measured.* Take 1 pound of white arsenic

* Arsenite of lime is often made by boiling 1 pound of lime with 2 pounds of white arsenic in 1 gallon of water for thirty to forty-five minutes. This results in a paste of arsenite of lime, which settles in the solution. One quart of this mixture is used per barrel of water or Bordeaux mixture, but unless the stock solution is always stirred equally well, the amount of poison in a quart will be quite variable, with varying effectiveness; hence the clear solution of arsenite of soda as in the above formula is preferable.

and 4 pounds of crystal salsoda (2 pounds only of *anhydrous* salsoda are necessary), and boil together in 1 gallon of water for twenty minutes. This forms a stock solution of arsenite of soda, which may be kept until needed. Put it in a jug and label "Poison." When ready to spray add a quart of this solution and 3 or 4 pounds of freshly slaked lime to each barrel of water (50 gallons). When used at this rate the arsenite of lime will cost about 7 cents for a barrel, exclusive of labor in its preparation, as compared with 10 cents for an equal amount of Paris green ($\frac{1}{3}$ lb.), or 20 cents for arsenite of lead (2 lbs.). Unless large quantities are to be used for the purposes indicated, it will hardly pay the small user to bother with its manufacture, and the danger of poisoning in the mixing or in the careless disposal of waste or uncleaned utensils must also be considered, though it may sometimes be useful in an emergency when manufactured arsenicals are not available.

6. *Resin-soap Sticker.*—Upon the smooth foliage of such plants as cabbage and asparagus it is exceedingly difficult to stick Paris green or even arsenate of lead when used as a spray. To obviate this the addition of resin-soap acts as a sticker. Place 5 pounds of pulverized resin and 1 pint of fish-oil or any cheap animal oil, except tallow, in an iron kettle with 1 gallon of water, and heat until the resin is softened; add the lye solution as made for hard soap; stir thoroughly; add enough water to make 5 gallons and boil about two hours, or until the mixture will unite with cold water, making a clear, amber-colored liquid. If the mixture has boiled away too much, add sufficient water to make 5 gallons. This makes a stock solution of liquid resin soap. For use add three gallons to 50 gallons of water, and add 3 gallons of milk-of-lime or whitewash (3 lbs. stone lime in 3 gallons), and $\frac{1}{4}$ pound of Paris green. The addition of lime turns the small soap particles into hard soap to which the Paris green adheres and is thus distributed throughout the mixture in uniform quantity and rendered exceedingly adhesive. The stock solution may be added directly to Bordeaux mixture without the addition of extra lime, to which Paris green or arsenate of lead may be added in the usual quantity. Similar resin soap,

called sticker, is sold by James Good of Philadelphia, Pa., and may be used in the same way at the rate of 3 pounds to 50 gallons.

7. *Poisoned Bran Mash.* For combating grasshoppers and cutworms arsenic is often applied in the form of a bran mash. Mix 1 pound of Paris green or London purple (or white arsenic colored with a dye) with 25 pounds of bran or middlings. Stir a quart or two of cheap molasses into a gallon of water and moisten the bran, stirring thoroughly, until it makes a stiff mash. Do not add so much water that the mash will be thin and will cake when exposed. Apply a heaping tablespoonful near each plant or every 2 or 3 feet in the row. Keep poultry out of fields thus treated. For cutworms apply a day or two before setting plants and as near evening as possible.

8. *Hellebore.* The powdered roots of the white hellebore are often used as an insecticide in place of arsenicals, especially for currant worms, rose slugs, and similar saw-fly larvæ and for insects affecting crops soon to be eaten, as the hellebore is much less poison to man and animals than arsenicals. It may be applied dry, diluted with from 5 to 10 parts of flour, or as a spray, 1 ounce to a gallon of water. It is too expensive to use except for a few plants in the yard or garden, and like pyrethrum, deteriorates with age and if exposed to the air.

Harmlessness of Arsenicals when Properly Applied. The question is frequently asked whether it is safe to apply arsenicals to vegetables and fruits to be used as food. Where sprayed or dusted as directed the amount of arsenic which would be deposited on the plant would not be sufficient to cause any injury, and Professor C. P. Gillette has shown that twenty-eight cabbages dusted in the ordinary way would have to be eaten at one meal in order to produce poisonous effects. Occasionally growers dust cabbage with an unreasonable amount of poison, and very rarely instances of poisoning are recorded, but there is no value in applying any more poison than is necessary to make a thin film over the surface, and more than that is wasted. Because a certain amount of poison will kill an insect does not indicate that a larger amount can kill it any "deader." Experiments have also shown that tobacco sprayed as

recommended cannot possibly bear enough arsenic to be injurious, and that cattle or horses may be pastured under trees sprayed with arsenicals with impunity.*

2. Contact Insecticides

Contact insecticides are used against insects with sucking mouth-parts and soft-bodied biting insects, which may be more readily destroyed by this means than by arsenicals. These substances are fatal to the insect either by clogging the spiracles or trachea, and thus causing suffocation, or by corroding the skin. It should be remembered that the chitinous skin of most insects is not easily corroded, and that in most cases a material strong enough to penetrate the skin will also injure foliage, so that only soft-bodied insects can be combated with corrosive substances upon foliage.

In the application of contact insecticides *it is absolutely essential that the spray come into contact with the insect*, as a mere spraying of the foliage is of no value whatever.

1. *Kerosene emulsion* is one of the oldest remedies for plant-lice, and other sucking and soft-bodied insects, and is often resorted to because it is readily made and the materials are always at hand.

Dissolve ½ pound of hard or whale-oil soap (or 1 quart soft soap) in 1 gallon of boiling water. Add 2 gallons of kerosene and churn with a force pump by pumping back and forth for five to ten minutes until the oil is thoroughly emulsified, forming a creamy mass with no drops of free oil visible. This stock solution is now diluted so that the resulting mixture will contain the desired per cent of kerosene. Thus for aphides one part of the stock solution should be diluted with from 10 to 15 parts of water, giving from 4 to 6 per cent of kerosene in the spray, while for a winter wash for San José scale, it should be diluted only three or four

* This is not true of grass beneath trees which have been sprayed with a straight-jet fire-hose, as is commonly done in Massachusetts in the extensive operations against the gypsy moth, but refers to spraying which has been done with an ordinary spray nozzle, which applies the material as a fine spray.

times, giving from 16 to 22 per cent kerosene. The emulsion must be thoroughly churned and should be applied with a nozzle throwing a fine spray. Apply only enough to wet the insects. Equally effective emulsions may be made from crude petroleum, the proportion of the soap and crude oil in the stock emulsion varying with the quality of the oil. Emulsions made with some of the crude oils seem to be much less injurious to foliage of some plants than when made with kerosene. Such an emulsion is made in California from distillate oils and is known as distillate emulsion. We have used crude Texas oils with equal success.

2. *Kerosene.*—Pure kerosene should never be used on foliage, for though occasionally someone will report using it successfully without injury, in practically all cases serious burning of the foliage results. It was formerly recommended against the San José scale on fruit trees, but such serious injury resulted that it has been almost entirely discarded, though it may be used on apple and pear trees if applied with a nozzle which throws a fine spray, on a bright sunny day, and only a very thin film applied to the tree while it is dormant, but even these trees are often injured if the application is not made with the greatest care.

3. *Crude Petroleum.*—Crude petroleum is used in the same manner as kerosene against scale insects, but seems to be less injurious to the tree, and has been extensively used in New Jersey against the scale on peaches, where but little injury has resulted where it has been carefully applied. It contains more heavy oils and consequently does not penetrate the bark so readily, and the light oils evaporating leave the heavy oils on the bark for some months, which aid in preventing young scales from getting a foothold. Crude oil for use as an insecticide should have a specific gravity of from 43° to 45° Beaumé scale, and is sold by certain Eastern companies as "insecticide oil."

4. *Oil and Water Treatment.*—Spray pumps have been sold for several years which make a mechanical mixture of oil and water in desired proportions. These have been thoroughly tested both by entomologists and by extensive use by practical fruit-growers and the general verdict is that they are unreliable and unsatisfac-

tory. None of them now on the market give a uniform percentage of oil, and injury to foliage is therefore liable to result. With the advent of miscible oils the oil-and-water pump is not to be recommended.

5. *Miscible Oils.* During the last few years several manufacturers have placed on the market under various trade names what are now called miscible oils. These are petroleum rendered soluble by the addition of vegetable oils, cut or saponified with an alkali, and are really a sort of liquid petroleum soap which will combine readily with water. They have been used principally as winter washes against the San José scale, for which they are most effective when diluted 10 or 12 times. For a summer wash they have been used effectively against plant-lice and other insects for which kerosene emulsion would be used, diluted 25 to 30 times. In barrel lots the miscible oils sell at 40 to 50 cents per gallon, thus making the cost of a gallon of mixture for a winter application at 10 per cent, 4 or 5 cents per gallon.

6. *Whale-oil and Other Soaps.*—Any good soap is an effective insecticide for destroying aphides and young or soft-bodied larvæ. Any good laundry soap made into a thick solution one-half pound per gallon is an excellent remedy for such insects on house-plants. Whale-oil or fish-oil soap has been extensively used against scale insects and plant-lice. The best brands are made from caustic potash rather than caustic soda, and should contain not over 30 per cent of water, there being wide variation in the water content. For the pea aphis and other aphides 1 pound to 6 gallons of water has been found very effective. For a winter wash for the San José scale 2 pounds per gallon of water are applied while hot, the soap being dissolved in hot water. The soap can be bought for 3½ to 4 cents a pound in large quantities, thus making the treatment for scale cost from 7 to 8 cents a gallon.

7. *Lime-sulfur Wash.*—The lime-sulfur wash has always been the standard remedy for the San José scale on the Pacific Coast, and during the last few years has come into wide use in the East for the same pest. It has also been found to be an efficient

remedy for the pear leaf blister-mite, and the oyster-shell bark-louse. In addition to its insecticidal properties it is an excellent fungicide, and the spring applications just before the buds start are very effective in killing out the wintering spores of various fungous diseases, while the diluted wash is being used as a summer spray for fungous diseases in place of Bordeaux mixture.

The usual formula is, unslaked stone lime, 20 pounds; flowers (or flour) of sulfur, 15 pounds, water to make 50 gallons. Stir up enough water with the sulfur to make a thick paste. Slake the lime in the vessel in which it is to be cooked with a small quantity of hot water. Then add the sulfur paste to the slaking lime. Add 10 or 15 gallons of water and boil for forty-five minutes. The mixture may then be diluted to make a barrel of 45 or 50 gallons, straining it carefully into the spray barrel or tank. A large iron kettle or hog-scalder may be used for boiling the wash, or where steam can be made available a steam pipe may be run into several barrels and the wash boiled in them. Such barrels may well be placed upon a platform so that the wash may be drawn from them directly into the spray-tank. The materials for making the wash will cost $1\frac{1}{3}$ to $1\frac{1}{2}$ cents per gallon and the labor practically as much more. The leading manufacturers and dealers in insecticides are now selling concentrated lime-sulfur solution which is all ready for use by merely diluting to the desired strength, at a rate which will make the solution to be used cost from $2\frac{1}{2}$ to 3 cents per gallon, nearly as cheap as it can be made at home and with the saving of time and a disagreeable job. In many communities a central plant makes the wash and can sell it with a fair profit at a low rate.

8. *Home-made Concentrated Lime-sulfur.*—During the last few seasons many large growers have been making their own concentrated lime-sulfur solution, and where the quantity to be used warrants, a considerable saving may be effected. The New York Agricultural Experiment Station has made very careful studies* of the best methods of making and diluting the mixture from which the following is quoted:

*Bulletins 329 and 330, N. Y. (Geneva) Agricultural Experiment Station.

GENEVA STATION FORMULA FOR CONCENTRATED LIME-SULFUR SOLUTION.

Lime	Pure CaO	36 lbs.
	If 95 per cent pure	38 lbs.
	If 90 per cent pure	40 lbs.
Sulfur, high grade, finely divided		80 lbs.
Water		50 gals.

DILUTIONS FOR DORMANT AND SUMMER SPRAYING WITH LIME-SULFUR MIXTURES

Reading on hydrometer.	Amount of Dilution. Number of Gallons of Water to One Gallon of Lime-sulfur Solution.		
	For San José Scale.	For Blister-mite.	For Summer Spraying of Apples.
Degrees Beaumé.			
36	9	12½	45
35	8¾	12	43¼
34	8¼	11½	41½
33	8	11	40
32	7½	10½	37¾
31	7¼	10	36¼
30	6¾	9½	34¼
29	6½	9	32¾
28	6	8½	31
27	5¾	8	29½
26	5¼	7½	27¾
25	5	7	26
24	4½	6½	24¼
23	4¼	6	22¾
22	3¾	5½	21¼
21	3½	5	19¾
20	3¼	4¾	18¼
19	3	4¼	17
18	2¾	4	16
17	2½	3¾	15
16	2¼	3½	14
15	2	3	12¾

"In making, slake the lime in about 10 gallons of hot water, adding the lumps of lime gradually to avoid too violent boiling and spilling over. . . . The sulfur must be thoroughly moistened and made into an even, fluid paste without lumps (before adding to the lime). . . . Pour in the sulfur paste gradually during the slaking, stirring constantly to prevent the formation of lumps, and when the slaking has finished add the full amount of water

and boil gently for one hour. If kettles and fire are used, more than the required amount of water may be used at first, to compensate for evaporation, or the volume may be kept constant by adding successive small quantities to hold the mixture at the original level, as shown by a notch on a stick resting on the bottom of the kettle, and marked when the mixture first begins to boil. When boiling with live steam the mixture will be more likely to increase in volume than to decrease, so that no water need be added.

"This concentrate will keep with little change, unless the weather is below 5° F., if stored in filled, stoppered barrels. Even in open receptacles there will be no loss if the surface be covered by a layer of oil to prevent access of air. Each boiling should be tested with a Beaumé hydrometer * and its density marked on the barrels or other containers."

The dilution is based upon the specific gravity as shown by the hydrometer and may be safely made according to the outline in the above table.

In making this mixture it is important that only high-grade, pure lime should be used, and lime with less than 90 per cent calcium oxid (CaO) should be discarded.

9. *Self-boiled Lime-sulfur.*—Self-boiled lime-sulfur has proven to be the only safe fungicide for the foliage diseases of the peach and stone fruits, and is used extensively as a summer spray on pome fruits. As a winter wash for San José scale it has not proven as effective as the boiled mixture, but when used as a summer spray for fungous diseases it also has considerable insecticidal value. Its general usefulness as a summer insecticide is in the process of experimental determination, but sufficient results have already been secured to warrant the statement that it will prove of considerable value as a summer insecticide for certain pests, where it is to be used for the fungous diseases of the host plant at the same time. This mixture has been developed

* These hydrometers, made specially for testing lime-sulfur mixture, may be obtained from the Bausch & Lomb Optical Co., Rochester, N. Y., and other dealers in laboratory glassware.

chiefly by the work of Mr. W. M. Scott of the United States Department of Agriculture, from whose latest bulletin * the following is quoted:

"In order to secure the best action from the lime, the mixture should be prepared in rather large quantities, at least enough for 200 gallons of spray, using 32 pounds of lime and 32 pounds of sulfur. The lime should be placed in a barrel and enough water (about 6 gallons) poured on to almost cover it. As soon as the lime begins to slake the sulfur should be added, after first running it through a sieve to break up the lumps, if any are present. The mixture should be constantly stirred and more water (3 or 4 gallons) added as needed to form at first a thick paste and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted, and applied.

"The stage at which cold water should be poured on to stop the cooking varies with different limes. Some limes are so sluggish in slaking that it is difficult to obtain enough heat from them to cook the mixture at all, while other limes become intensely hot on slaking, and care must be taken not to allow the boiling to proceed too far. If the mixture is allowed to remain hot for fifteen or twenty minutes after the slaking is completed, the sulfur gradually goes into solution, combining with the lime to form sulfids, which are injurious to peach foliage. It is therefore very important, especially with hot lime, to cool the mixture quickly by adding a few buckets of water as soon as the lumps of lime have slaked down. The intense heat, violent boiling, and constant stirring result in a uniform mixture of finely divided sulfur and lime, with only a very small percentage of the sulfur in solution. It should be strained to take out the coarse particles of lime, but the sulfur should be carefully worked through the strainer."

10. *Sulfur.*—Pure sulfur is one of the best remedies for red

* Farmers' Bulletin, 440, U. S. Dept. of Agr., p. 34.

spider, on whatever plants it may occur, and for other mites which infest citrus fruits. It may be dusted on the infested plants or trees or applied with any other insecticide, using 1 or 2 pounds to 50 gallons. For citrus-mites the lye-sulfur wash and sulfide of lime are extensively used. Sulfur is frequently dusted in poultry houses to rid them of lice, and may be mixed with lard and rubbed on the skin of domestic animals affected with lice.

11. *Pyrethrum*, buhach, or Persian insect powder, is made by pulverizing the petals of the pyrethrum blossom, and kills insects by clogging their breathing pores. It is not poisonous to man or domestic animals and may therefore be used where other insecticides would be objectionable. It is chiefly used for household pests, and in greenhouses and small gardens. It deteriorates rapidly with age and should be kept in tight cans. An objection to much commonly bought is that it has been kept in stock too long by the retailer, thus losing its strength. Large users buy direct from the only American manufacturers, the Buhach Producing Co., Stockton, Cal. It may be used as a dry powder, pure or diluted with flour, or in water at the rate of 1 ounce to 2 gallons, which should stand a day before using. For immediate use it should be boiled in water for five or ten minutes. It is frequently burnt in rooms to destroy mosquitoes and flies, for which it is effective, without leaving any odor after the room is aired.*

12. *Tobacco.*—A tobacco decoction may be made by boiling or steeping tobacco leaves, stems, and refuse in water at the rate of 1 pound to 1 or 2 gallons. This may be diluted slightly according to the strength of the tobacco and the insect to be combated. Such a decoction is an excellent remedy for dipping plants affected with aphides, and may be used as a spray for plant-lice and similar soft-bodied insects. Various extracts and solutions of tobacco are now sold by manufacturers which are extensively used in spraying against plant-lice, and which are proving more satisfactory on account of their uniform strength. Tobacco dust has been used successfully against root-infesting aphides by removing the sur-

* See Farmers' Bulletin, 444, U. S. Dept. Agr., p. 7.

face soil and applying a liberal dressing of the dust and then covering. The rains leaching through the tobacco carry the tobacco water to the affected roots and destroy or repel the aphides.

3. Repellants

Repellants include any substance which may be applied to a plant or animal to prevent insect attack. A popular notion that any vile-smelling substance will repel insect attack seems to have very little evidence in its support. Tobacco dust, air-slaked lime, or even fine road dust, thoroughly covering a plant will prevent the attack of various flea-beetles and leaf-eating beetles, but to be successful the plants must be frequently dusted and kept well covered. Bordeaux mixture, our most widely used fungicide, when liberally sprayed on potatoes and tomatoes, acts as a repellant to the little black flea-beetles which often seriously damage the young plants.

The various fly-sprays which are used for spraying cattle to prevent the annoyance of flies act merely as repellants.

Fruit-trees are often painted with a thick soap solution containing 1 pint of crude carbolic acid to 10 gallons as a repellant for the adult borers which lay their eggs on the bark.

A substance which has come into prominence in the fight against the gypsy moth in New England is tree tanglefoot, a sticky substance the same as is used to coat fly-papers. This comes in the form of a very sticky paste, a band of which is placed around the trunk of the tree and which prevents the ascent of caterpillars, as it will remain sticky for some weeks. It may be used in the same way to prevent the wingless female canker worms and other wingless insects from ascending trees, or to prevent the ascent of caterpillars on unaffected trees.

Various proprietary insecticides are frequently offered for sale with wonderful claims for their effect as repellants, but only in rare cases are they of any value except for use as a dust as already suggested. One of the most common fakes of this sort is that of the itinerant tree-doctor who offers to bore a hole in a tree and plug it with sulfur or other offensive compounds, which will effectively

prevent any insect or fungous depredations. A generous price per tree is charged, which is the only "effect" of the treatment.

4. Gases.

Carbon Bisulfid (or disulfid) is extensively used against insects affecting stored goods and grains, and for root-feeding insects. It is a clear, volatile liquid giving off fumes heavier than air. It is sold in 25- to 100-pound cans at 10 to 12 cents per pound. It may be thrown directly onto grain without injury to it or placed in shallow dishes. For grain in store in fairly tight rooms apply 5 to 8 pounds to every 100 bushels, distributing the bisulfid over the surface or in pans containing not over one-half to 1 pound each. Make the enclosure as tight as possible; covering the grain with blankets or other tight cover, if necessary, and leave for twenty-four hours. Recent experiments have shown that the vapor is much less effective at low temperatures and that the dosage must be greatly increased at temperatures below 60° F. For fumigating buildings "there should be about 1 square foot of evaporating surface to every 25 square feet of floor area, and each square foot of evaporating surface should receive from one-half to 1 pound of liquid." For fumigating clothing or household goods, place them in a tight trunk and place an ounce of liquid in a saucer just under the cover. The gas is exceedingly explosive; allow no fire or light of any kind around the building or enclosure until it has been well aired. The fumes should not be inhaled, for though not seriously poisonous, they have a suffocating effect and will soon produce dizziness and a consequent headache. The treatment for root-maggots and root-feeding aphides is discussed in connection with those insects (pages 355 and 496).*

Hydrocyanic Acid Gas is extensively used for the fumigation of nursery trees and plants, certain greenhouse insects, pests of dwelling houses, storehouses, mills, etc., and in California for scale insects on fruit trees. It is made by combining cyanide of

* For a complete discussion of the use of this gas, see Farmers' Bulletin, 145, U. S. Dept. Agr., and see page 197 below.

Carbon tetrachloride is now used for some purposes in much the same manner as carbon bisulphide, and is not so explosive.

potassium, sulfuric acid and water. The gas is slightly lighter than air and is a most deadly poison. Its use is to be recommended only by thoroughly competent and careful persons who are fully advised as to the method of use for the particular purpose desired. Concerning its use advice should be sought from the State Agricultural Experiment Station, or from the State Entomologist, or from the Bureau of Entomology of the U. S. Department of Agriculture. The general methods used are fully described by the late Professor W. G. Johnson in his book "Fumigation Methods", (Orange Judd Co.), with which should be considered the results of more recent experiments and experience.

Sulfur Dioxid.—The fumes of burning sulfur, mostly sulfur dioxid, have long been recognized as a standard remedy for the fumigation of dwellings and barracks for insect pests. Successful fumigation for the bedbug has been reported when stick sulfur has been burned at the rate of 2 pounds per 1000 cubic feet of space. The chief objection is the strong bleaching effect of the fumes in presence of moisture and their destructive action on vegetation. Recently this gas has been extensively used under the name of "Clayton gas," for the fumigation of ships and ships' cargoes, particularly grain. It is forced into the tight hold of a ship by special apparatus and is exceedingly penetrating and effective. The germinating power of seeds is quickly destroyed, but they are not injured for food. 1 to 5 per cent of the gas, with an exposure of twenty-four hours, is effective for most seed and grain pests. It cannot be used on vegetation or for moist fruits.

Tobacco Fumes.—Tobacco is extensively used as a fumigant for aphides in greenhouses and for certain plants, such as melons, by using it under covers. Several forms are now commonly used. Tobacco or nicotine extracts are sold under various trade names, which are volatilized by heating either with a small lamp or by dropping hot irons into the dishes containing the fluid. The same material may be purchased in the form of paper which has been saturated with the extract and which is burned according to directions, a certain amount being sufficient for so many cubic feet of space, which forms a more convenient method of

application. Certain finely ground tobacco powders, called "fumigating-kind" tobacco powder, are used in the same way and are much the cheapest form of tobacco for fumigation, though requiring slightly more work in preparing for fumigation. These tobacco preparations are excellent for the fumigation of household plants, which may be placed in a closet and then fumigated according to the directions of the particular brand employed. Melon vines, young apple trees, bush fruits, and similar outdoor crops may be effectively rid of plant-lice by fumigating with tobacco-paper under a frame covered with canvas or muslin sized with glue or linseed oil.

For further discussion of Insecticides see Farmers' Bulletin 127, U. S. Department of Agriculture.

CHAPTER VI

SPRAYING AND DUSTING APPARATUS

Atomizers.—Hand atomizers of the general style shown in Fig. 26 may be purchased at any hardware store, and are useful for applying soap or oil solutions to a few house or garden plants. They are not adapted for more extensive use and to try to spray many plants, or a tree, with them, is a waste of time.

Bucket Pumps.—The simplest type of spray pump is that made to use in a bucket. The better types usually cost $5 to $8, the cheaper styles, selling for $2 or $3, being inferior and unsatisfactory.

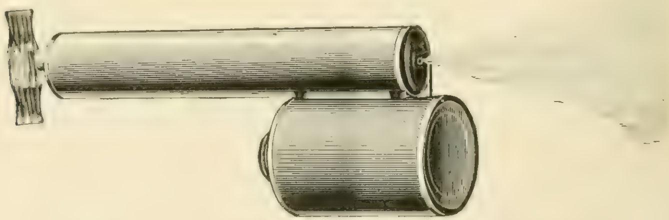


Fig. 26.—An atomizer handy for spraying a few plants.

There is as much difference in the structure of bucket pumps as in those of the barrel type, and many of the statements made below concerning the latter will apply also to bucket pumps. The bucket pump should have an air chamber, so that a steady pressure may be maintained. Some firms are making bucket pumps of the same general type of the barrel pump shown in Fig. 34, which are very satisfactory in this regard. A footrest attached to the pump and a clamp to attach the pump to the bucket are useful accessories.

Many firms are now selling these pumps mounted in large galvanized-iron covered buckets, and furnished with a mechanical agitator. This is a desirable arrangement, for the buckets are much larger than those ordinarily used, thus saving frequent filling, while the cover prevents slopping, and the pump is always ready for use without the necessity of hunting up a bucket and then cleaning it, which is necessary after using a bucket which is used for other purposes.

Bucket pumps are useful for small gardens or for a few small trees, or bushes.

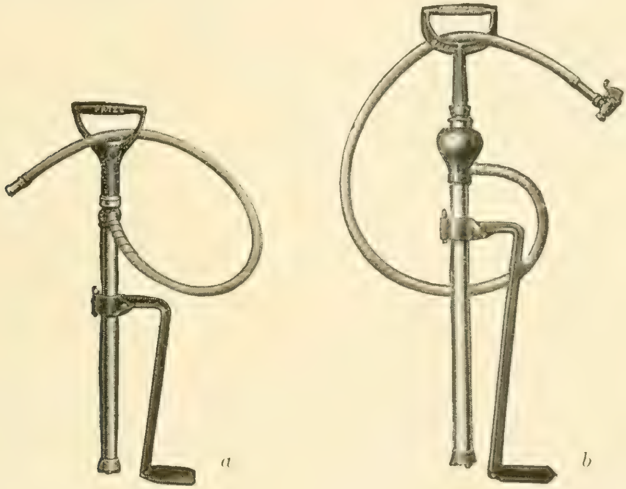


FIG. 27.—*a*, a cheap type of bucket pump with no air-chamber, which will not maintain satisfactory pressure; *b*, a better type of bucket pump with small air-chamber. (Courtesy Deming Co.)

Knapsack Pumps.—The knapsack pump consists of a copper or galvanized-iron tank carried on the back like a knapsack, in which is mounted a bucket pump with a lever handle for pumping. In the better makes this handle is detachable, and a plain handle may be attached so that the tank may be used as a simple bucket pump, for which a footrest is attached to the tank. The pump should have a good mechanical agitator. The copper tanks are preferable, for Bordeaux mixture will soon eat through galvanized iron. Knapsack pumps are useful for spraying such

crops as tomatoes, melons, etc., which cover the ground, so that it is difficult to drive through them without injuring the vines, crops growing on steep hillsides, or for a small acreage of any garden crops, small fruits, or small trees. The main objections to them are that they are heavy to carry, thus limiting their use to a small area; they frequently slop over, and wet the carrier's back; and the pumps do not develop sufficient pressure for some kinds of work. Consequently they are not as much used as formerly, but are useful for the purposes indicated, and inasmuch as they may also be used as a simple bucket pump, they are to be preferred to them. The cost varies from $8 to $12 or $15.

Fig. 28.—Bucket pump mounted in bucket, and mounted in tank with agitator. (Courtesy Deming Co.)

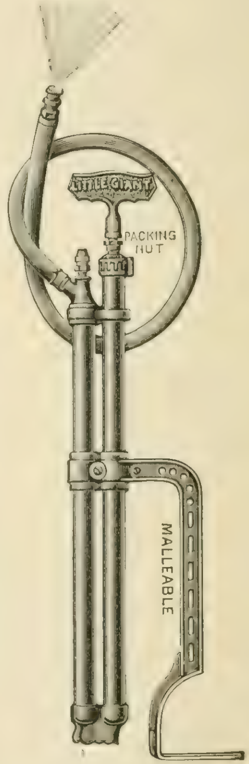


Fig. 29.—Bucket pump with large air-chamber, which will maintain a good pressure. (Courtesy F. E. Myers & Bro.)

Compressed-air Sprayers.—In recent years the compressed-air sprayer has come into favor for use in small gardens. It consists of a brass tank which is filled with the liquid; the air

is compressed by an air-pump, and spraying continues until the pressure runs down, when a stopcock is turned and the pressure is again raised by pumping. The tank holds from 3 to 5 gallons, and is carried beneath one arm, slung by a strap over the other shoulder. The chief objections to this type are that it is not very convenient to fill, though the newer models are much improved, is not readily repaired, has no agitator, and requires frequent pumping. On the other hand, they are easily carried, do not leak, and leave both hands free, so that one might be used for spraying a small tree from a stepladder. These compressed-air sprayers cost from \$5 to \$8.

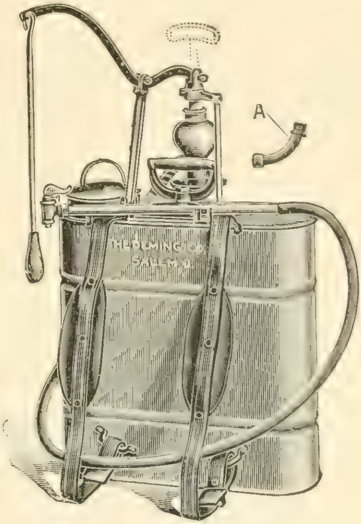


FIG. 30.—One of the best types of knapsack sprayers. Note footrest, agitator, handle, and wide straps. (Deming Co.)

Barrel Pumps.—The most serviceable spray pump for the average farm is the barrel pump. With a good barrel pump 100 to 150 full-grown apple trees may be sprayed in a day, so that it will be found sufficient for an orchard of 500 trees or less. By using a row-spraying attachment, a few acres of pota-

FIG. 31.—The knapsack sprayer in use. (Spramotor Co.)

toes or other row crops may be sprayed with a barrel pump much more quickly than by hand. In buying a row attachment, be sure that it is adjustable for rows of different widths. A good barrel pump costs from $15 to $25. Most of the pumps sold at $10 or less are too light to do effective work or are not well constructed. Numerous pump companies advertise in the agricultural papers, and after considering the following points one may select a suitable pump from their catalogs:

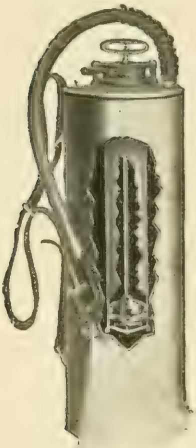
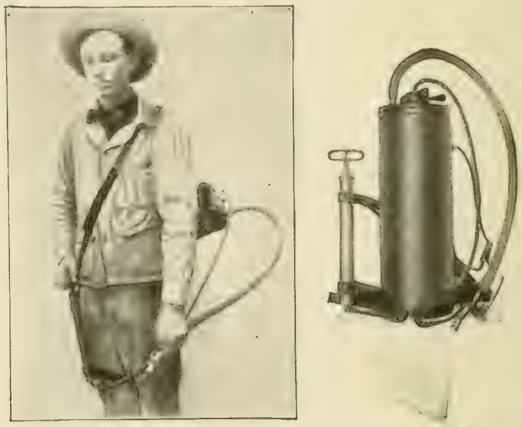


FIG. 32.–Compressed-air sprayer with section of tank removed to show air pump within.



New type of compressed-air sprayer with separate pump. (E. C. Brown Co.)

1. The pump should be guaranteed to furnish four nozzles at 80 to 100 pounds' pressure with ordinary pumping.

2. It should have a large air chamber within the barrel, and not projecting above it.

3. As few of the working parts of the pump as possible should be above the head of the barrel, as exposed parts are easily broken.

4. The cylinder, plunger, valves and working parts should be of brass. The handles and other parts commonly made of cast iron are much more durable when made of malleable or galvanized iron.

5. There should be a good mechanical agitator of the paddle type, preferably arranged so that it can be worked with the pump handle without operating the pump. An agitator is essential to keeping the mixture in suspension. Agitators of the so-called "jet-type," in which a stream from the bottom of the

FIG. 33.—An undesirable type of barrel sprayer—now off the market; the air-chamber and other parts above the barrel render it top-heavy, and may be easily broken.

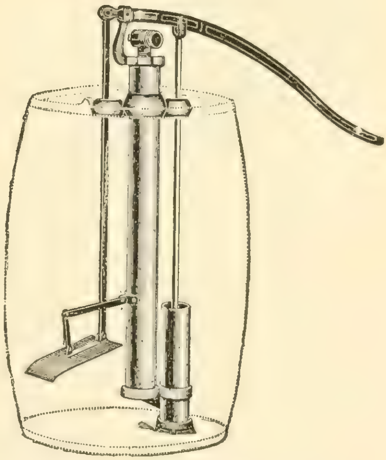


FIG. 34.—A desirable type of barrel pump embodying most of the features described. (Morrill & Morley.)

cylinder is supposed to agitate the liquid, are unsatisfactory and allow a loss of pressure without sufficiently agitating the liquid.

6. The pump should be so attached to the barrel that it can be quickly removed for repairs. Those pumps which have lugs for attaching the pump plate to the barrel are much better than those with screws.

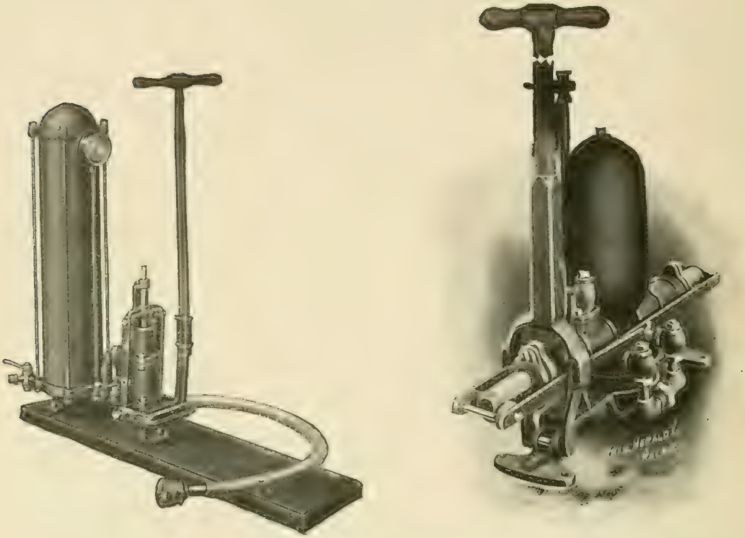


FIG. 35.—Two types of double-acting lever pumps, to be mounted on truck and connected with tank.

FIG. 36—Double-acting horizontal pump mounted on 250-gallon tank. A good type of outfit for medium sized commercial orchards. (Va. Agr. Exp. Sta.)

8. The valves, with their seats or cages, should be readily removable for cleaning, and should be so constructed that they remain evenly ground.

All of these points may not be embodied in any one pump, but most of the better pump manufacturers are embodying these features in their newer models, a good example of which is shown in Fig. 34.

Barrel, knapsack, and bucket pumps are manufactured which have separate tanks for oil and water which are mixed in a desired proportion and sprayed as a mechanical mixture. They have been found unreliable in controlling the amount of oil, and are not now in general use.

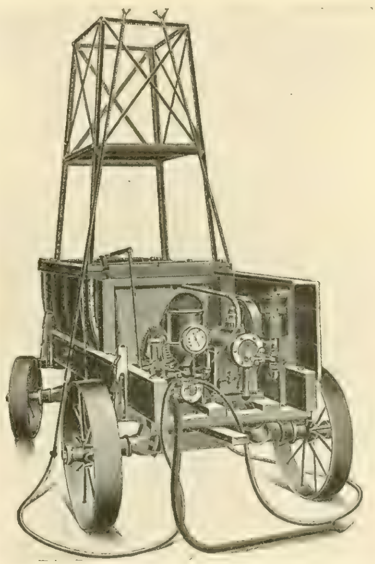


FIG. 37.—Gasoline power sprayer, complete. Note wide tread steel wheels, steel tower on tank, and intake hose for filling tank where running water is not available; 3½ h.p., 4-cycle gasoline engine, will maintain 10 nozzles at 200 lbs. pressure.

Horizontal Pumps.—For larger orchards and shade trees, the double-acting horizontal pumps which are operated with a lever, as shown in Fig. 35, furnish more power and consequently make more rapid work possible. They are mounted on 100- or 150-gallon tanks and may be arranged for filling the tank where running water is not available. These pumps cost from $30 to $50 and will maintain 100 to 125 pounds pressure with four to eight nozzles. They are usually used with two men spraying and another driving and pumping, or a fourth man pumps and changes places now and then with the driver, as the operation of this type is rather too heavy for one man constantly.

Fig. 38.—One of the latest three-cylinder power pumps, designed for spraying shade-trees and woodlands.

Fig. 39.—Row-spraying attachment for use with barrel pump, adjustable for various width of rows. (Deming Co.)

Power Outfits.—For orchards of much over 500 trees or for extensive shade-tree work a gasoline power outfit is more economical and enables a large area to be covered more quickly, which is often a most important consideration. Most of the pump manufacturers and many gas engine companies are selling such outfits mounted upon a truck, with spray tank, and tower complete for from \$250 to \$400.

Traction Sprayers.—For a small acreage of potatoes or other

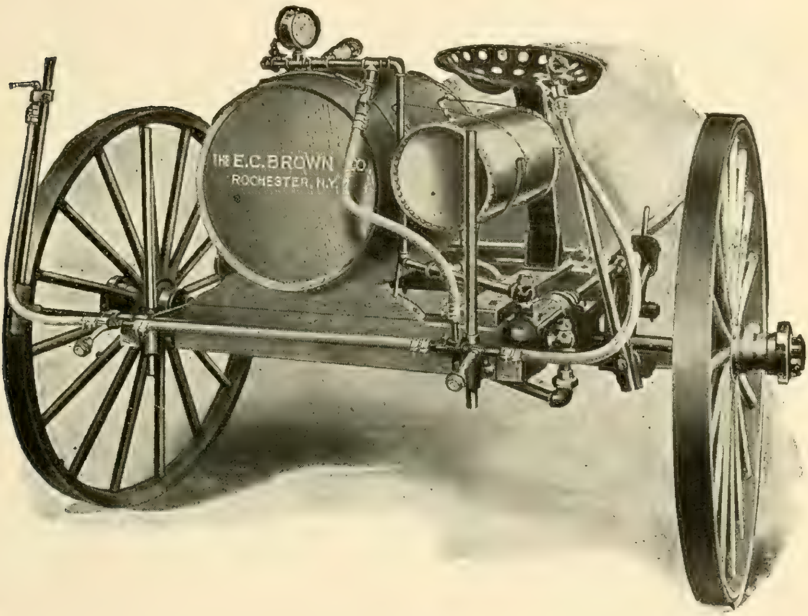


FIG. 40.—A good type of geared sprayer for row crops.

row crops, a barrel pump with row attachment is very satisfactory, but for any considerable acreage, a two-wheeled traction sprayer is much more economical of labor and time which are the two chief items in the cost of spraying. Such traction sprayers are made of widely different types, the power in all cases being furnished by a gear or chain which operates the pump from the wheels. The mechanical construction of the traction sprayers should be carefully studied, and if possible tested, before

purchasing, as they differ greatly in efficiency. The better types cost from \$60 to \$100, and usually have attachments adapting them for all sorts of row crops, such as potatoes, strawberries, bush fruits, grapes, etc., which require different styles of piping to properly direct the nozzles.

Several traction sprayers are sold for orchard work but, though they are fairly satisfactory for small trees, they do not develop enough power for spraying large trees, and have a heavy draft.

Gas Sprayers.—A very handy and efficient spraying outfit is now

FIG. 41.—Row sprayer applying arsenate of lead to potatoes, showing arrangement of nozzles to cover vines. (After Britton.)

made which uses carbonic-acid gas as the power (Fig. 42). The liquid is placed in a steel-tank, to which is attached a tube of carbonic-acid gas, the same as is used for soda fountains. The gas is admitted to the tank by a valve until the desired pressure is secured, and the gas then forces the liquid out, thus obviating the need of a pump. The outfit is mounted on a steel truck with steel tower, or may be mounted on any wagon, and is also mounted on two wheels with suitable attachments for row spraying. The cost of the gas is somewhat higher than gasoline or hand power, but less labor is required

and constant high pressure is maintained. Unfortunately the gas makes a chemical combination with lime-sulfur mixture, so that this type of sprayer is not adapted for its use. A modification of the gas sprayer outfit has recently been made in which a gasoline engine operates an air-compressor, which places an air pressure on the liquid in the tank in the same manner as would the compressed carbonic-acid gas. It is claimed that these outfits are superior to an ordinary gasoline engine and pump, in that the liquid does not pass through the pump, and that

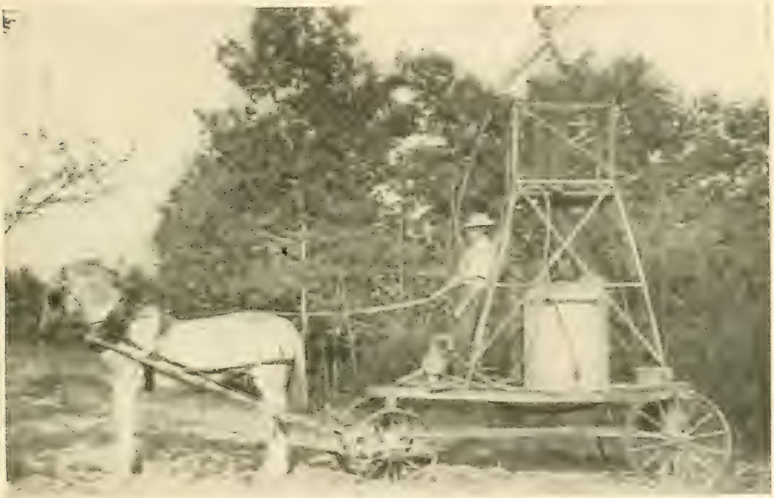


FIG. 42.—Carbonic-acid gas sprayer at work.

there is therefore less wear on the pump, and that the outfit is lighter.

A somewhat similar use of compressed air is being made for orchard sprayers by a few large fruit growers. The outfit consists of two steel tanks holding 50 to 100 gallons each, which are fitted with valves connecting them and at the outlet. One of these tanks is filled with liquid and in it is an agitator operated from the wheel. The other tank is charged with compressed air by an air-compressor stationed at the filling-station. The air-pressure secured in the air-tank is sufficient to force all

of the liquid out of the other tank at a pressure never below 100 pounds, and averaging 125 to 150 pounds. The advantages of these outfits are that they are much lighter, so that more liquid can be carried, and that the men on the outfit need have no mechanical ability, as is necessary with the operation ofa gasoline engine pump. The trucks and tanks are much cheaper than the gasoline sprayers, but the cost of the engine and air-compressor at the charging station makes the total cost probably more. It is also necessary for each tank to return to the charging station, and it is not possible to use a supply tank, as is commonly done with gasoline sprayers. However, these outfits are in successful operation by some of the largest orchardists, who believe them to

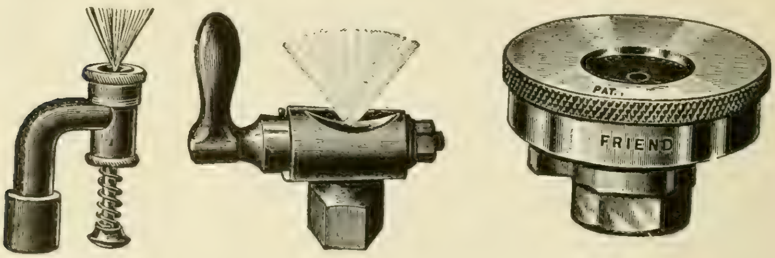


FIG. 43.—Vermorel, bordeaux, and disk type of nozzles.

be much the best type of sprayers for large operations, so that they merit study by those contemplating extensive spraying.

Nozzles.—A good nozzle is as essential as a good pump for successful spraying. The best nozzles now in common use are of three types.

The Vermorel type consists of a small chamber into which the liquid is admitted at a tangent and leaves through a small hole in a removable cap, thus making a fine, cone-shaped spray. A small pin, with a spring to hold it back when not in use, serves as a disgorger to remove any sediment which may clog the outlet. This type of nozzle is made in many slightly different styles and often sold under trade names, such as the Demorel, Mistry and others. A slightly modified form has no spring attached to the disgorger, but has a loose cap which is held away from the pin by the force of

the liquid, and the outlet is disgorged by simply pressing the cap down on the pin. Such are the Spramotor (Spramotor Mfg. Co.) and Vapor-Mist Nozzles (Field Force Pump Co.) and are disgorged rather more easily than those with springs. The Vermorel type makes the finest spray of the three types of nozzles and will therefore be preferred for use with oils and fungicides where a very fine spray is desired. The liquid must be thoroughly strained, for they are easily clogged. Usually two or three nozzles are attached to a Y, T, or ring, for orchard or shade tree work.

Disk Type.—An evolution from the latter type has recently been brought out in which the chamber has been made much broader and flatter, thus giving a very strong rotary motion to the liquid and breaking it into a fine spray through a large aperture, so that no disgorger is required. This is known as the *disk type* of nozzle, and was originated by the Friend Mfg. Co., but is now sold by all the leading pump companies in various forms under different trade names. The nozzle is light, does not catch on twigs, and the large aperture prevents clogging, even of unstrained liquid, and allows the passage of a large amount of liquid, one of these nozzles spraying as much as two or three Vermorels. This type was designed for use with power sprayers, but will give good

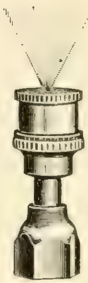



FIG. 44.—A cluster of spramotor nozzles and single nozzle of the same type.

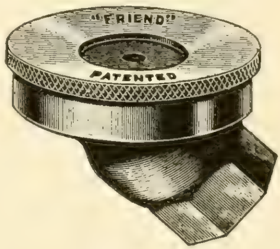


FIG. 45.—Angle form of disk type nozzle, particularly useful for orchard spraying. (Friend Mfg. Co.)

results with barrel or horizontal pumps which will maintain a pressure of 85 pounds or more. One of these nozzles to each line of hose will be sufficient with a barrel pump, and two to a line with power. The disk type is adapted to orchard and shade-tree work.

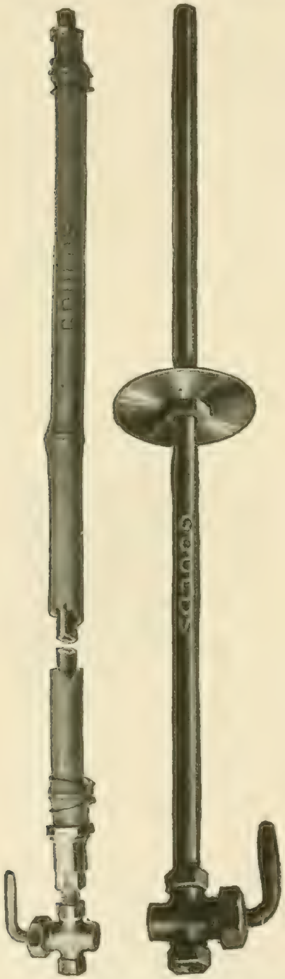


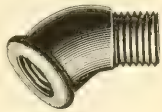
FIG. 46.—Bamboo extension rod at left, and iron rod with drip-guard at right.

The Bordeaux nozzle is of entirely different structure, the spray being formed by a straight stream hitting a lip which breaks it into a fan-shaped spray, the fineness of the spray being governed by the width of the aperture. To unclog the nozzle the core through which the stream emerges is reversed, thus giving a straight stream and clearing the nozzle immediately. For this reason the Bordeaux nozzle is particularly adapted to traction sprayers where several nozzles are used and it is necessary to unclog them quickly. It is usually preferred for garden and row crops, and some prefer it for tree work, though it is not as widely used for that purpose as the previous types.

At the present time these three types of nozzles are much superior to all others, and the user will do well to stick to them and let others experiment with new or cheap creations until they have proven themselves better. Nozzles which merely sprinkle or make a strong long stream are undesirable for spraying.

Extension Rods.—In orchard spraying an extension rod is a necessity. Most pump companies sell a bamboo rod enclosing a light brass tube, and fitted with thread for the nozzle at the tip and

with a shut-off or stopcock at the lower end, so that the stream may be cut off when moving from tree to tree and the pressure maintained. These are light and easily handled, but the bamboo and connections frequently break, so that many prefer using a straight piece of three-eighths or one-half inch galvanized-iron pipe, threaded for the nozzle and stopcock. Wooden handle-grips, or grips made of burlap, may be wired around the pipe, so that it will be easier to hold. Ten feet is a good length.



45-degree elbow for attaching nozzles to end of rod for orchard spraying.

The nozzle should be attached to the rod by a 45-degree connection, so that it points at that angle. This enables one to spray directly over the topmost branches and under the lower ones, making the work much easier and more effective than where the nozzle is attached straight.

FIG. 46.—Spraying squash with underspray nozzle at right angle to rod.

In spraying low-growing crops, such as melons, beans, etc., upon which it is desirable to spray the under surface of the foliage, a short pipe about 3 feet long is usually used, with the nozzle attached to it by an L, so that the nozzle is at right angles to the pipe and will spray the under surface.

Hose.—Use the best four-ply one-half-inch hose for barrel or power sprayers and three-eighths-inch for bucket or knapsack sprayers. For barrel or power sprayers use couplings with double-length shanks which will permit the use of two clamps or bands on either side of the union. Wire bands for attaching hose to pump or nozzle are unsatisfactory and should be avoided.

Fig. 47.—The old way: attempting to spray tall apple-trees from the ground and making very hard work of it.

Fig. 48.—The modern way: spraying apple-trees from a rough tower bolted to a one-horse wagon.

Strainers.—To obviate the delay caused by nozzles clogging with dirt and sediment, strain all mixtures through a fine copper strainer when filling the spray tank. Have the tank tight and see that it is clean before filling.

Towers.—For orchard spraying it is essential that the operator be high enough to spray all parts of the tree quickly and thoroughly. Most of the power outfits are built with a tower such as shown in Fig. 37. A very serviceable tower may be erected on a one- or two-horse wagon, at slight expense. It is bolted to the body, so that it is easily removed. The floor should be as high

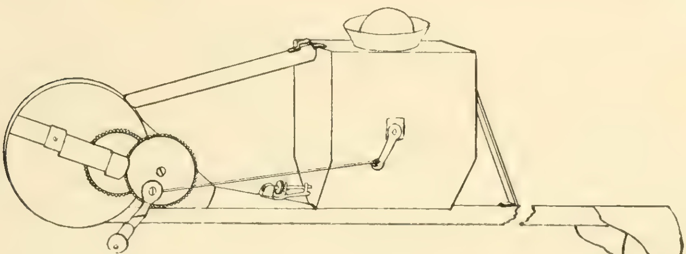


Fig. 49.—A powder-gun for applying insecticides in dust form. (After Weed.)

as the weight of the wagon and roughness of the land will allow. and the railing should be about the height of the sprayer's waist.

Dusting Apparatus.—For dusting a few plants a small powder bellows may be used, but where crops are to be dusted a powder gun will be found much more economical. One of the best types is shown in Fig. 49. This has tubes which will direct the dust onto two rows if desired and regulates the amount of dust used. Larger traction outfits mounted on two wheels are made for dusting row crops, but hand work with the smaller machine has usually proven more effective. Larger outfits are also made for carrying in a wagon for dusting orchards. These have been used extensively in the Ozark region, but the use of dust has not proven as effective for most purposes as the spray, though it is superior for some purposes, as for the cotton boll

weevil (see p. 272), and may sometimes be used where it is difficult to secure or haul water.

Other mechanical devices for combating particular insects will be described in connection with them.*

* For further information see "Information Concerning Spraying for Orchard Insects," A. L. Quaintance, Yearbook, U. S. Dept. Agr., for 1908, p. 267.

CHAPTER VII

Insects Affecting Grains, Grasses, Forage and Miscellaneous Crops

SEVERAL of our worst insect pests live normally in grass land, but when they become numerous feed upon grains and various forage and garden crops, so that they are not readily classed as enemies of any one crop, and will therefore be discussed together.

White Grubs *

Among the most common pests of corn, strawberry beds, and garden crops are the large white grubs which feed upon the roots and often kill the plants. Their habit of lying curled up in a semicircle, and the large brown head, white body, and enlarged abdomen, at once distinguish them from other forms of grubs. Although they are very similar in color and form, there are numerous species, all of which are the young of different species of the large brown May-beetles or June-bugs, as they are commonly called, which frequently fly into lights in late spring.

Life History.—The eggs are laid mostly in June, preferably in grass land, but also in corn fields and gardens. The egg is of a broad oval shape, pure white, about one-tenth inch long, and is laid in a small ball of earth a half inch in diameter, from 1 to 5 inches below the surface. The eggs hatch in about two weeks, most of them hatching by the middle of July. The young grubs feed upon plant roots, and grow slowly, as it requires two years or more for them to become full-grown. In the fall they burrow down in the soil, gradually going deeper

* *Lachnosterna* spp. Family—*Scarabæidæ*. See S. A. Forbes, Bulletin 116, Illinois Agricultural Experiment Station.

as frost approaches until by the first freeze most of them are from 7 to 14 inches deep. The next year they do much more serious damage, and land which has been in sod and then planted in corn, strawberries, or other crops of which they are fond, is often so full of the grubs that the crops are ruined. In 1895 an Illinois field of 250 acres which had been in grass for twenty years was so injured that the sod could be rolled up like a carpet over the entire field. It is not surprising, therefore, that Professor Forbes records finding as many as thirty-four grubs to the hill of corn in another Illinois field which had previously been in sod. Where sod is taken into greenhouses the grubs

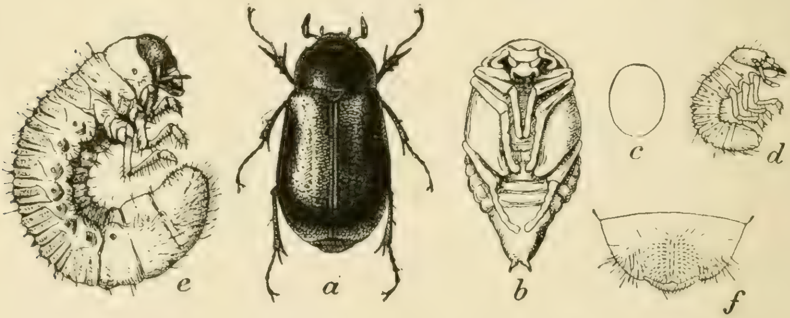


FIG. 50.—*Lachnosterna arcuata:* *a*, beetle; *b*, pupa; *c*, egg; *d*, newly-hatched larva; *e*, mature larva; *f*, anal segment of same from below. *a*, *b*, *e*, enlarged one-fourth; *c*, *d*, *f*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

often become serious pests. When the grub is two, or possibly sometimes three years old, it forms a small oval cell from 3 to 10 inches below the surface and there changes to a soft, white pupa, sometime in June or July. The pupal stage lasts slightly over three weeks, and in August or September the adult beetle wriggles out of the pupal skin, but remains in the pupal cell until the following spring, when it comes forth fully hardened. Thus three full years are occupied by the life-cycle of each brood, though grubs in all stages of development may be found in the soil every year.

The adult beetles feed at night upon the foliage of various trees. They hide in the soil during the day, migrate to the trees

at dusk, and return to the fields just before daybreak. The different species have favorite food plants, but all of our common deciduous shade and forest trees are more or less eaten, poplar, willow, and maple being particularly relished. On a warm evening the beetles may often be heard feeding and their work may be identified by the ragging of the foliage, as if it had been torn.

Control.—As allowing land to remain in grass for several years is conducive to the increase of the grubs, a frequent rotation will prevent their multiplication, the grass being followed by potatoes, buckwheat, small grains, or some crop not seriously injured by them.

As the beetles remain in the pupal cells over winter and are tender and not fully hardened, deep plowing and thorough harrowing in fall or early spring will kill large numbers of them by breaking open the cells and exposing them to the weather and by burying and crushing them.

Swine will gorge themselves on grubs in badly infested land, and if confined so that they will thoroughly root it over, will very effectually rid it of them. Flocks of chickens or turkeys following the plow will catch a considerable number of grubs, as do the crows and blackbirds, which pay for the corn they eat by the war they wage on grubs.

The beetles may be jarred from the trees upon which they are feeding in the cooler part of the night and collected, as is extensively done in Europe. Lanterns hung over pans or tubs containing water with a surface film of kerosene placed near the trees on which they feed, will catch large numbers on warm nights when they are flying.

Wireworms*

Wireworms are hard, shining, slender, cylindrical, brown larvæ about three-quarters to 1 inch long, which bore into the seed of corn, wheat and other grains, often necessitating replanting, and also feed on their roots, as well as on potatoes, turnips, and many garden crops. They are the young stage of

* Family *Elateridæ*.

brownish beetles of the family *Elateridæ,* which from their habit of snapping their bodies up in the air are known as "click beetles." The beetles are one-half to three-quarters inch long, decidedly flattened, dark brown, often with darker markings, with short heads, and shield-shaped thoraxes, as shown in Fig. 50. Although the common wireworms look much alike, examination usually reveals that they belong to several species which are distinguished by a comparison of the caudal segments, as shown in Fig. 51.

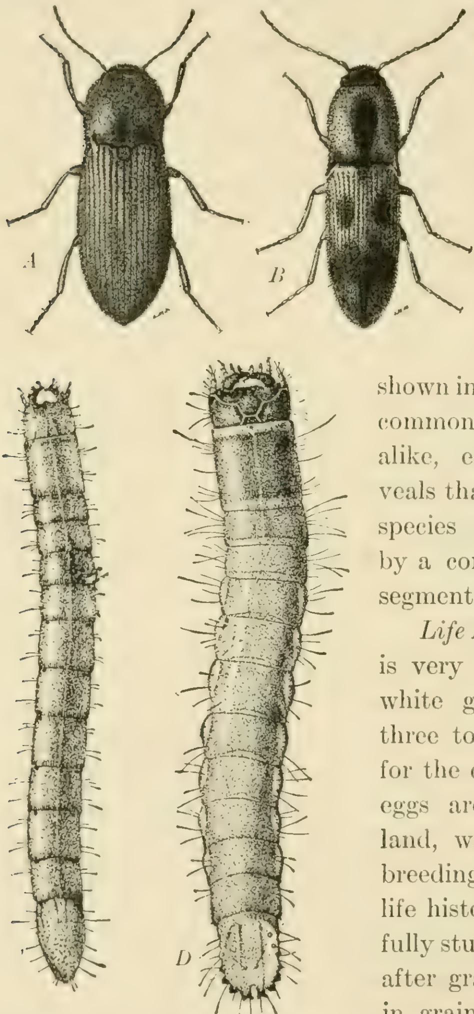


FIG. 50.—*A*, beetle of wheat wireworm (*Agriotes mancus*) ×4; *B, D*, beetle (×4) and wireworm (×7) of *Drasterius elegans; C*, the corn wireworm (*Melanotus cribulosus*) ×4½. (After Forbes.)

Life History.—The life history is very similar to that of the white grubs, except that from three to five years are required for the complete life cycle. The eggs are deposited in old sod land, which is the favorite breeding ground. The detailed life histories have not been carefully studied, but the second year after grass land has been planted in grain is that in which the worst injury occurs, particularly with corn, upon which the attack is more concentrated than with small grains. The larvæ become full grown in midsummer, form small cells in the soil

and in them transform to pupæ. Three or four weeks later the adult beetles shed the pupal skins, but few of them make their way to the surface during the fall, most of them remaining in the pupal cells until the following spring.

Control.—As they resemble the white grubs in life-cycle, so the means of control are similar. By plowing in late summer or early fall and thoroughly harrowing for a month or so, large numbers of the pupæ and newly transformed beetles will be destroyed. When the wireworms are numerous in restricted areas, as they often are on spots of low moist land, they may be effectually trapped with but little labor by placing under boards bunches of clover poisoned with Paris green. A short rotation

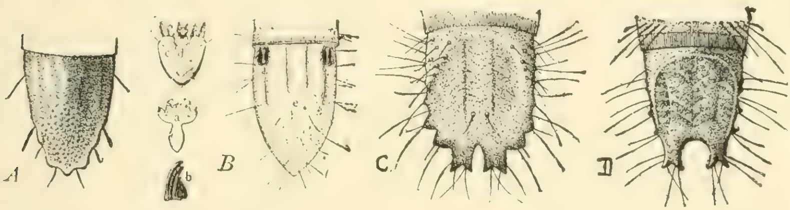


FIG. 51.—*A*, last segment of *Melanotus communis*, dorsal view (After Forbes); *B*, the wheat wireworm, *Agriotes mancus*—*a*, *b*, *c*, *d*, details of mouth-parts, enlarged; *C*, caudal segment of the wireworm of *Drasterius elegans*; *D*, caudal segment of the wireworm of *Asaphes decoloratus*, much enlarged. (*A*, *C*, *D*, after Forbes; *B*, after Slingerland.)

of crops in which land is not allowed to remain in grass for any length of time will prevent their increase. Many remedies have been suggested for these pests, but few of them have proved to have much merit in careful tests. Coating the seed with gas tar, as is done to protect it from crows, has been very widely practiced, and though previous experiments indicated that it could not be relied upon, Dr. H. T. Fernald conducted tests in Massachusetts in 1908 and 1909 in which seed coated with gas-tar and then dusted in a bucket of fine dust and Paris green sufficient to give the corn a greenish color, was effectively protected, the treatment seeming to act as a repellant, and not affecting the germination of the seed.

Cutworms*

Under the general term *cutworms* we commonly designate any of the larvæ of several species of moths, which are more or less similar in general appearance and habits, and which have the habit of feeding on low-growing vegetation, and cutting off the stem just at the surface of the ground. They should be carefully distinguished from white grubs, which are sometimes

FIG. 52.—Earth removed from base of seedling to show cutworm in hiding—natural size.

wrongly called cutworms on account of their similar habits. Some of the species attack certain crops more commonly than others, but most of them are quite omnivorous in their feeding. When they become overabundant they will eat anything green and succulent—foliage, flowers, buds, fruit, stalks, or roots, and sometimes migrate to other fields in armies like the army worms. Some species commonly climb young fruit trees which have been

* Various species of the family *Noctuidæ*.

planted on grassy land or which are allowed to grow in grass

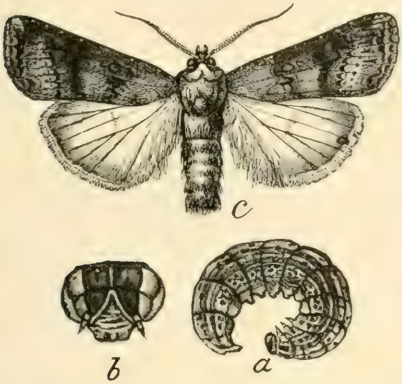


FIG. 53.—Greasy cutworm (*Agrotis ypsilon*); *a*, larva; *b*, head of same; *c*, adult — natural size. (After Howard, U. S. Dept. Agr.)

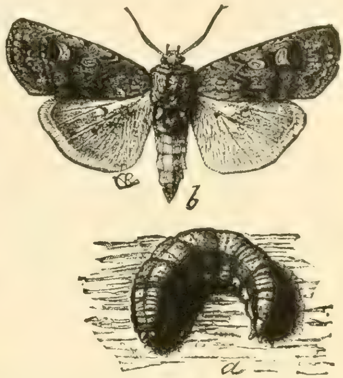


FIG. 54.—The dark-sided cutworm (*Agrotis messoria*). (After Riley.)

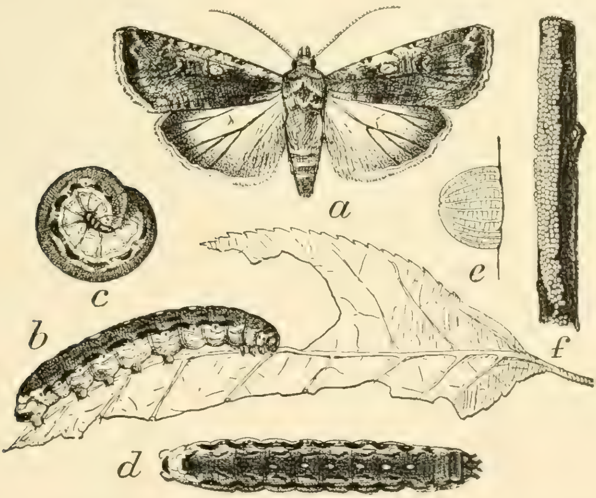


FIG. 55.—*Peridromia saucia*: *a*, adult, *b*, *c*, *d*, full-grown larvæ; *e*, *f*, eggs all natural size except *e*, which is greatly enlarged. (After Howard, U. S. Dept. Agr.)

or weeds, and are known as climbing cutworms. Our common species are most injurious to garden crops and to corn, cotton,

tobacco and similar crops grown in hills or rows, small grains and forage crops being injured but rarely.

Though over a score of species are common, it is not practicable to distinguish them in this discussion, and though their life histories are somewhat different, they may be considered as a class.

The adults are moths with dark fore wings, variously marked with darker or lighter spots and narrow bands as shown in Figs. 52–59, and with lighter hind-wings, which are folded over the back when at rest. Like the cutworms, they feed at night, sipping the nectar from flowers, and are known as owlet moths. The females deposit their eggs in grass land or where a crop has been allowed to grow up in grass and weeds in late

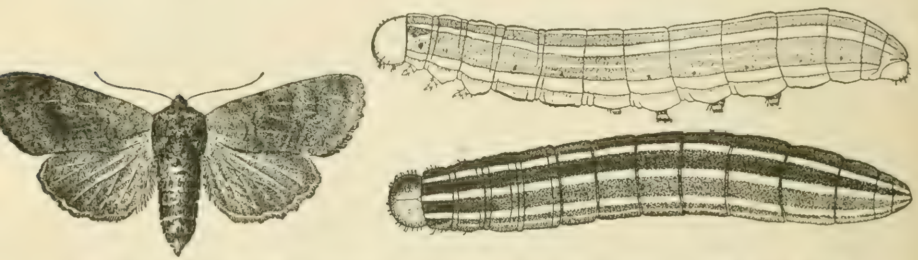


FIG. 56.—The bronzed cutworm (*Nephelodes minians* Guen.): back and side views of larva—enlarged, and moth—natural size. (After Forbes.)

summer, laying them in patches on the stems or leaves of grasses or weeds, or on stones or twigs in such places.

The little caterpillars which hatch from these eggs in August and September feed on the roots of whatever vegetation is available until frost, going deeper as it approaches, and finally hollow out small cells, in which they curl up and hibernate until the next spring. The next spring they are exceedingly hungry after their long fast, and attack any vegetaton at hand with surprising voracity. If the land is in grass or weeds they have plenty of food, and if it is then plowed and planted in some crop, it will certainly be injured.

The cutworms usually become full grown during late spring or early summer, and are then about 1½ to 2 inches long, of a dull brown, gray or blackish color, often tinged with green-

ish, and more or less marked with longitudinal stripes, oblique dots and dashes, the markings usually being of a subdued tone, so that the cutworm harmonizes in color with the soil. They are cylindrical, with the head and prothoracic plate horny and reddish brown, and bear three pairs of jointed legs

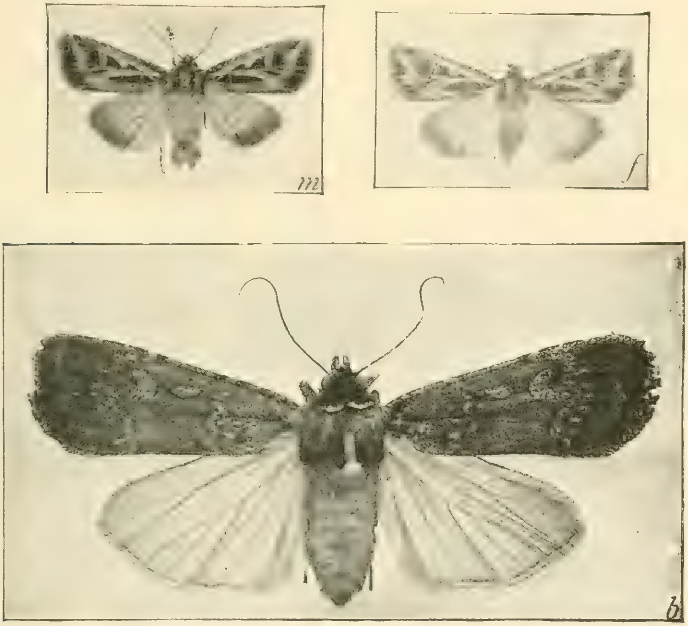


FIG. 57.—Cutworm moths: *b*, the well-marked cutworm-moth (*Noctua clandestina* Harris); the dingy cutworm (*Feltia subgothica* Haworth); male (*m*) and female (*f*) moths. (After Slingerland.)

on the thorax and five pairs of prolegs on the abdomen. The mature caterpillars pupate in cells a few inches below the surface and in three or four weeks the adult moths emerge, usually in July and early August in the Central and Northern States and earlier farther south.

Thus there is usually but one generation a year in the North while in the South there are commonly two generations and in some cases three. Though other stages than the larvæ of various species are known to sometimes hibernate, nevertheless

the worst injury is usually done in the spring, when young plants have just been set or are just appearing.

Control.—It is evident from their life history that like the white grubs and wireworms, cutworms may be most effectually combated by plowing in late fall and again plowing and harrowing thoroughly in early spring, so as to keep the land fallow and thus starve them out. Land which is to be planted in corn or crops subject to cutworm injury should be plowed as early as possible in late summer of the preceding year and kept fallow so that the moths will not deposit their eggs upon it, as they will if it is left in grass or weeds.

FIG. 58.—Moth of the glassy cut-worm (*Hadena devastatrix* Brace). (After Forbes.)

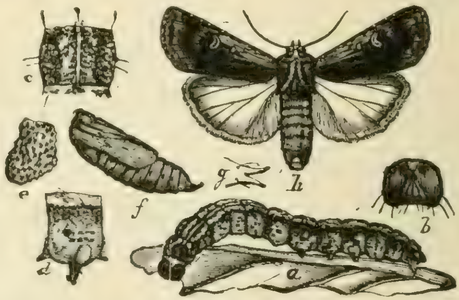


FIG. 59.—Granulated cut-worm (*Agrotis annexa*). *a*, larva; *f*, pupa; *h*, adult—natural size. (After Howard, U. S. Dept. Agr.)

Poisoned bran mash (see p. 47) is probably the best thing for destroying cutworms, and if well applied a few days before plants are set or a few days after seed is planted, will often protect crops on infested land. On corn land it may be applied with a seed drill, and in gardens an onion drill is sometimes used in the same way, placing the mash on the surface near the plants; or it may be applied by hand, placing a tablespoonful near each plant or every 2 or 3 feet in the row. Distribute the mash late in the afternoon, so that it will still be moist when the worms feed at dusk. Keep poultry away from fields so treated. Clover which has been thoroughly sprayed or dipped in water containing one-third pound Paris green per barrel may be used in the same way, particularly along the outside of fields to be protected from invasion or along borders of fields next to grass.

Market gardeners frequently protect cabbage, tomato and similar plants by knocking the bottoms out of tin cans or making cylinders of building paper and placing these around the stems, sinking them into the soil. Where cutworms assume the climbing habit and attack fruit trees, distribute the bran mash or poisoned clover liberally around the bases of the trees and put a band of tanglefoot around the trunk of each tree, which will prevent their ascent. Thorough cultivation of the orchard and neighboring land will also reduce their numbers. When they assume the migratory habits of army worms, they may be controlled by the same methods as described for them. Garden plants may sometimes be protected from cutworms, as well as flea beetles, by dipping them in arsenate of lead, 3 pounds per barrel, when planting.

The Chinch-bug *

The adult Chinch-bug is about one-fifth inch long, with a black body. Its white wings lie folded over each other on the abdomen, and are marked by a small black triangle on their outer margins, while the bases of the antennæ and the legs are red. The young bugs are yellowish or bright red marked with brownish-black, becoming darker as they grow older. Along the Atlantic coast and along the southern shores of the Great Lakes north of a line from Pittsburg, Pa., to Toledo, Ohio, the majority of the adults have short wings reaching but half over the abdomen and are incapable of flight; but between the Alleghany and Rocky Mountains the long-winged form greatly predominates. It occurs also in restricted localities in Central America and along the Pacific coast. The worst injury is to small grains and corn in the Central and North Central States, but frequently injury is done in the Eastern States, especially to timothy meadows which have stood for several years. Though individually insignificant, when assembled in countless myriads chinch-bugs have doubtless been of greater injury to the farmers of the Mississippi Valley than any other insect attacking grain crops, the total damage from 1850 to 1909 being estimated at $350,000,000.†

* *Blissus leucopterus* Say. Family *Lygæidæ*.

† See Circular 113, Bureau Entomology, U. S. Dept. Agr., F. M. Webster.

Life History.—During the winter the bugs hibernate in clumps of grass, in the butts, and in old shocks of corn, or under whatever rubbish is available. In early spring they assemble in fields of grass and small grains. Soon they pair and the females commence to lay their small yellowish-white eggs upon the roots or bases of the stalks, each laying some 150 to 200 eggs.

The eggs are laid from the middle of April until the first of June, depending upon the latitude and weather, and hatch in two or three weeks. As the nymphs grow they often do serious injury to small grains and grass, upon which they become full grown about the time of harvest. When wheat is harvested they spread to oats and soon to corn, but, curiously enough, though

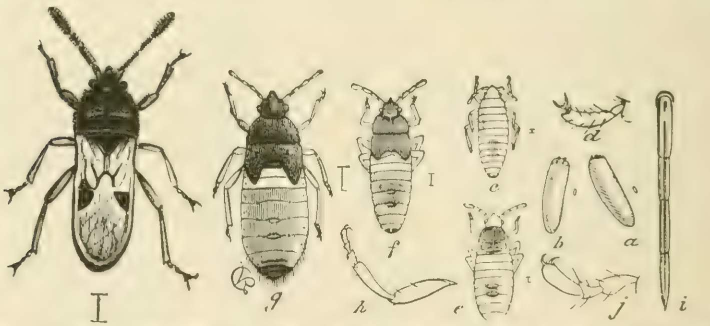


FIG. 60.—The chinch-bug (*Blissus leucopterus* Say): adult at left; *a*, *b*, eggs magnified and natural size; *c*, young nymph; *e*, second stage of nymph; *f*, third stage; *g*, full-grown nymph or pupa; *d*, *h*, *j*, legs; *i*, beak through which the bug sucks its food. (After Riley.)

the adults have wings they travel from field to field on foot, were it not for which fact we should be at a loss to cope with their migration. Eggs are now laid upon the unfolding leaves of the corn, from which the nymphs commence to emerge in about ten days. This second brood matures on corn in August and September and is the one which later hibernates over winter, though where corn is not available the whole season may be passed on grass.

Control.—The burning over of grass land, and the grass along fences, hedges, and roads, as soon as it becomes dry enough in late fall and early winter, is of prime importance to destroy the bugs after they have gone into hibernation. The removal

of all corn stalks from the fields and plowing the butts under deeply, or where the bugs are very abundant, raking out the butts and burning them, will rid the fields of the pest.

It is practically impossible to combat the pest in the summer

FIG. 61.—Corn-plant two feet tall infested with chinch-bugs. (After Webster, U. S. Dept. Agr.)

on grass or small grains, but its migration to corn or from field to field may be effectually checked. In dry weather a dust furrow may be used as a barrier to good advantage. Just before harvest plow a deep furrow around the field to be protected, or on the threatened sides, and thoroughly pulverize the soil by dragging a heavy log back and forth in the furrow, making

the side next the corn as steep as possible.* In attempting to climb this barrier, the dust will slide from under the bugs and large numbers will accumulate in the bottom of the furrow, where they will be killed by the heat of the soil if it has a temperature from 110° to 120° (air temperature of over 90°). Keep the furrow clean by dragging a log through it now and then. By sinking post-holes a foot deep every few feet in the bottom of the furrow the bugs will collect in them and may be crushed or killed with kerosene. Such a dust furrow will be of no value in showery weather, and is most effective in hot dry weather on light soil; it may often be used to advantage in combination with the following methods.

In place of the dust furrow or in combination with it, a strip of coaltar is often run around the field. The strip should be about the size of one's finger, which can be made by pouring from a watering can with the mouth stopped down, and should be run inside the dust furrow and with post-holes sunk along its outer edge. Sometimes it is run in a zig-zag line with the holes at the inner angles so that the bugs will be concentrated at the holes. These tar strips must be freshened whenever dust or rubbish covers them. The soil may be prepared for the tar strip by plowing a back furrow and packing the top with a roller or beating it hard with spades; or a strip of sod may be prepared by scraping away the grass with a farm scraper and then smoothing carefully with shovels or hoes; or a dead furrow may be run and the tar strip run on the smooth bottom. To maintain such a tar strip for four weeks costs about $2 a mile and has proven itself entirely practical and effective.

If the bugs have already become numerous in the outer rows of corn, most of them may be destroyed by spraying with kerosene emulsion (see p. 48) made to contain four per cent kerosene, applying it in the early morning or towards night. It costs 34 cents a

* Such a furrow may possibly be made more readily by plowing several furrows and harrowing the ground thoroughly until reduced to a fine mulch and then plowing a dead furrow through the middle, and then dragging this with a log, making the sides as steep as possible. With such construction the furrow will cost about three cents per linear rod.

barrel diluted, and a man will spray five acres per day, using a barrel per acre. Whale-oil soap, one-half pound to the gallon of water, has proven equally effective and cost $1.12 per barrel.

A blast torch, for which an attachment is furnished with many of the compressed-air sprayers, may be used to advantage for destroying the bugs in a dust furrow or along the tar line, or a spray of pure kerosene or crude petroleum may be used for the same purpose.

Extensive experiments have been made in Illinois and Kansas with the use of the muscardine fungus against the chinch-bug. Though occasionally the results seem to be profitable, and though it is undoubtedly effective in wet seasons and it may be well to distribute the fungus to places where it does not occur so that it may reduce the numbers of the bugs in wet seasons, it seems to be of very little value in dry seasons, when the injury is worst, and cannot be relied upon to check the increase of the pest when used according to the methods so far devised.

When chinch-bugs become abundant and their migration to corn seems imminent, the farmer should prepare to devote himself and as many hands as necessary to fighting them until their advance is checked, for delay will mean ruin, while the prompt use of the above methods will save the corn crop.

Grasshoppers or Locusts *

Plagues of destructive locusts—or what we Americans call grasshoppers—have been recorded since the dawn of history. In America the worst devastation was done by the flights of the Rocky Mountain or Migratory Locust (*Melanoplus spretus* Thos.), which swooped down upon the States of the western part of the Mississippi Valley in the years 1873 to 1876 in destructive clouds. Since then they have several times done considerable injury in restricted localities and are often destructive in northern Minnesota, the Dakotas, Montana and Manitoba, but they will probably never again be a plague in the Central States.

Concerning their recent distribution, numbers, and destruc-

* Various species of the family *Acrididæ*.

tiveness, Mr. W. D. Hunter reported after the season of 1897: "There was, this season, a general activity of this species throughout the permanent breeding region greater than at any time in many years. This was brought about by a series of dry years, which have resulted in the abandonment of farms in many places. It is, of course, well understood that the absence of serious damage since 1876 has been partially due to the settling up of valleys in the permanent region. I wish to make it clear, however, that the dryness is the primary and the abandoning a secondary cause."

The Rocky Mountain Locust

Let us first consider this, the most injurious species, as the other locusts differ from it in but few essential points other than in being non-migratory.

To correctly understand its habits the reader should first divide the area which this species affects into three parts. Of these the (1) "Permanent Region, including the highlands of Montana, Wyoming, and Colorado, forms the native breeding-grounds, where the species is always found in greater or less abundance." * (2) the Subpermanent Region, including Manitoba, the Dakotas, and western Kansas, is frequently invaded. Here the species may perpetuate itself for several years, but disappears from it in time. (3) The Temporary Region, including the States bordering the Mississippi River on the west, is that only periodically visited and from which the species generally disappears within a year.

Spread. - When for various reasons the locusts become excessively abundant in the Permanent Region they spread to the Subpermanent Region, and from there migrate to the Temporary feeding-grounds. It is the latter area which suffers most severely from their attacks, but, fortunately, they generally do not do serious injury the next year after a general migration. In the Subpermanent Region their injuries are more frequent than in the Temporary, but are hardly as severe or sudden as farther east. Migrating from their native haunts, flights of

* Bull. 25, U. S. Dept. Agr., Div. Entomology. C. V. Riley.

the grasshoppers usually reach southern Dakota in early summer, Colorado, Nebraska, Minnesota, Iowa, and western Kansas during midsummer, and southeastern Kansas and Missouri during late summer, appearing at Dallas, Texas, in 1874, and about the middle of October, and even later in 1876. As thus indicated, the flights are in a general south to southeasterly direction, while west of the Rockies they descend to the more fertile valleys and plains, but without any such regularity as eastward. While the rate of these flights is variable and entirely dependent upon local weather conditions, twenty miles per day may be considered a fair average. The flights are more rapid and more distance is covered in the early part of the season, when, while crossing the dry prairies, a good wind will often enable them to cover 200 to 300 miles in a day. As they first commence to alight in their new feeding-grounds their stay is limited to but two or three days, but later in the season it is considerably length-

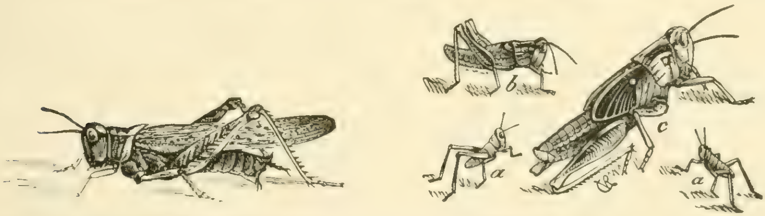


FIG. 62.—Rocky Mountain locust; adult and different stages of growth of young. (After Riley.)

ened, and, after a section is once infested, swarms will be seen to be constantly rising and dropping during the middle of the day.

Life History.—Over all the infested area, and while still sweep ing it bare of crops and vegetation, the females commence to lay their eggs, and continue to deposit them from the middle of August until frost. For this purpose " bare sandy places, especially on high, dry ground, which is tolerably compact and not loose," are preferred. "Meadows and pastures where the grass is closely grazed are much used, while moist or wet ground is generally avoided."

In such places the female deposits her eggs in masses of about thirty. These are placed about an inch below the surface in a pod-like cavity, which is lined and the eggs are covered by a

mucous fluid exereted during oviposition. From two to five hours are required for this operation, and an average of three of these masses is deposited during a period of from six to eight weeks.

As the time of ovipositing varies with the latitude, so the hatching of the eggs occurs from the middle or last of March in Texas till the middle of May or first of June in Minnesota and Manitoba. Until after the molt of the first skin, and often till after the second or third molt, the young nymphs are content to feed in the immediate vicinity of their birth. When the food becomes scarce they congregate together and in

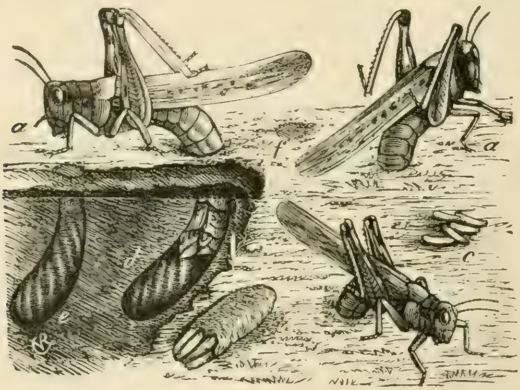


Fig. 63. Rocky Mountain locusts: *a*, *a*, *a*, females in different positions, ovipositing; *b*, egg-pod extracted from ground, with end broken open; *c*, a few eggs lying loose on ground; *d*, *e*, show the earth partially removed, to illustrate an egg-mass already in place and one being placed; *f* shows where such an egg-mass has been covered up. (After Riley.)

solid bodies, sometimes as much as a mile wide, march across the country, devouring every green crop and weed as they go. During cold or damp weather and at night they collect under rubbish, in stools of grass, etc., and at such times almost seem to have disappeared; but a few hours of sunshine brings them forth, as voracious as ever. When, on account of the immense numbers assembled together, it becomes impossible for all to obtain green food, the unfortunate ones first clean out the underbrush and then feed upon the dead leaves and bark of timber lands, and have often been known to gnaw fences and

frame buildings. Stories of their incredible appetites are legion; a friend informs me that he still possesses a rawhide whip which they had quite noticeably gnawed in a single night!

By mathematical computation it has been shown that such a swarm could not reach a point over thirty miles from its birthplace, and as a matter of fact they have never been known to proceed over ten miles.

Fig. 64.—A swarm of grasshoppers attacking a wheat-field. (After Riley.)

As the nymphs become full grown they are increasingly subject to the attacks of predaceous birds and insects, insect parasites, fungous and bacterial diseases, and are also largely reduced by the cannibalistic appetites of their own numbers. When the mature nymphs transform to adult grasshoppers and thus become winged, large swarms are seen rising from the fields and flying toward their native home in the Northwest.

This usually takes place during June and early July in the North, and as early as April in Texas, so that it is frequently impossible to distinguish the broods of the temporary region from the incoming brood which has migrated from the permanent region. Although the eggs for a second brood are sometimes laid, these seldom come to maturity, and the species is essentially single-brooded.

The Lesser Migratory Locust

Besides the Rocky Mountain locust there is only one other species that truly possesses the habit of migrating, though to a far lesser extent, and which is therefore known as the Lesser Migratory Locust (*Melanoplus atlantis* Riley). It is considerably smaller than its western relative and somewhat resembles the red-legged locust both in size and appearance. The species is very widely distributed, occurring from Florida to the Arctic Circle east of the Mississippi, and on the Pacific slope north of the fortieth parallel to the Yukon. The habits and life history of the species are in all essentials practically the same as the former species, except that they have no particular breeding-grounds. Injuries by this grasshopper were first noticed in 1743, almost seventy-five years before the first record of the Rocky Mountain locust, and since then it has done more or less serious damage in some part of the territory inhabited every few years.

Non-migratory Locusts

There are several species of locusts which, though lacking the migratory habit, and thus being more easily controlled, often become so numerous as to do serious damage over limited areas. Both as regards the regions inhabited, its habits, and life history, the common Red-legged Locust (*Melanoplus femur-rubrum* Har.) hardly differs from the last species, and is often found in company with it. It is non-migratory, however, and though the damage it does is thus entirely local, it is often of considerable importance.

Records of locust plagues in California date back as far as 1722. Many of them were doubtless due to the California Devastating Locust (*Melanoplus devastator* Scud.), and in the last invasion of 1885 this species outnumbered all others seven to one. Resembling the last two species in size and markings, the habits and life history of this species are also supposed to be similar to them, though they have not as yet been thoroughly studied.

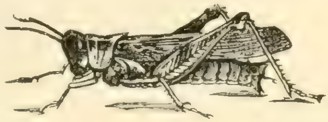


Fig. 65.—Red-legged locust (*Melanoplus femur-rubrum* Harr.). (After Riley.)

Together with the last species the Pellucid Locust (*Camnula pellucida* Scud.) has been largely responsible for the losses occasioned by locusts in California, and has also been found in New England, but is not noted there as specially destructive.

Fig. 66.—The pellucid locust (*Camnula pellucida* Scud.). (After Emerton.)

Our largest winged American locust, the American Acridium (*Schistocerca americana* Scud.), is practically confined to the Southern States from the District of Columbia to Texas, and thence south through Mexico and Central America, being rarely found in the North. This species is essentially a tropical one, and has often been exceedingly destructive, being especially so in 1876 in Missouri, Tennessee, North Carolina, Georgia, and southern Ohio.

Considerably larger than the preceding species are the Differential Locust (*Melanoplus differentialis* Thos.) and the Two-striped Locust (*Melanoplus bivittatus* Scud.), of which the former is peculiar to the central States of the Mississippi Valley, Texas, New Mexico, and California, while the latter has a more extended range from Maine to Utah and as far south as Carolina and

Texas. These two differ from the smaller species in laying only one or two masses of eggs, and the eggs of *differentialis*

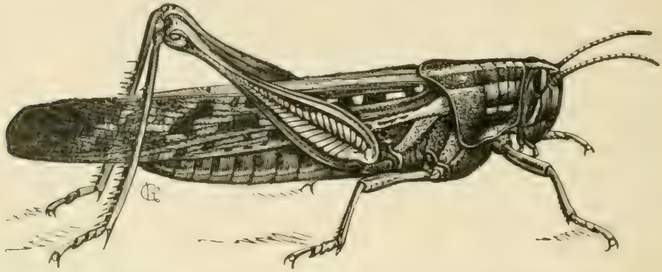


FIG. 67.—The American acridium (*Schistocerca americana* Scud.). (After Riley.)

have often been found placed under the bark of logs, but otherwise their habits are very similar. The two-striped locust is characterized by two yellowish stripes extending from the eyes along the sides of the head and thorax to the extremities of the wing-covers, and is probably the species most commonly observed by the farmer.

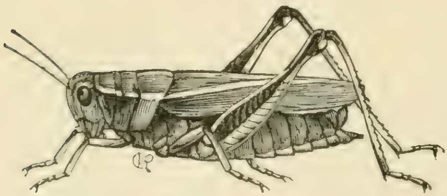


FIG. 68.—The Two-striped locust (*Melanoplus bivittatus* Scud.). (After Riley.)

The Differential Locust.—Throughout the Mississippi Valley from Illinois southward, the Differential Locust * is one of the

FIG. 69. The Differential locust (*Melanoplus differentialis* Thos.). (After Riley.)

most common and destructive grasshoppers, and is an excellent example of several of our more abundant and injurious species which have very similar habits.

* *Melanoplus differentialis* Thos.

The little grasshoppers hatch about the middle of May, from eggs which were laid in the fall, though we have observed them in March in Central Texas, and are of a dusky brown

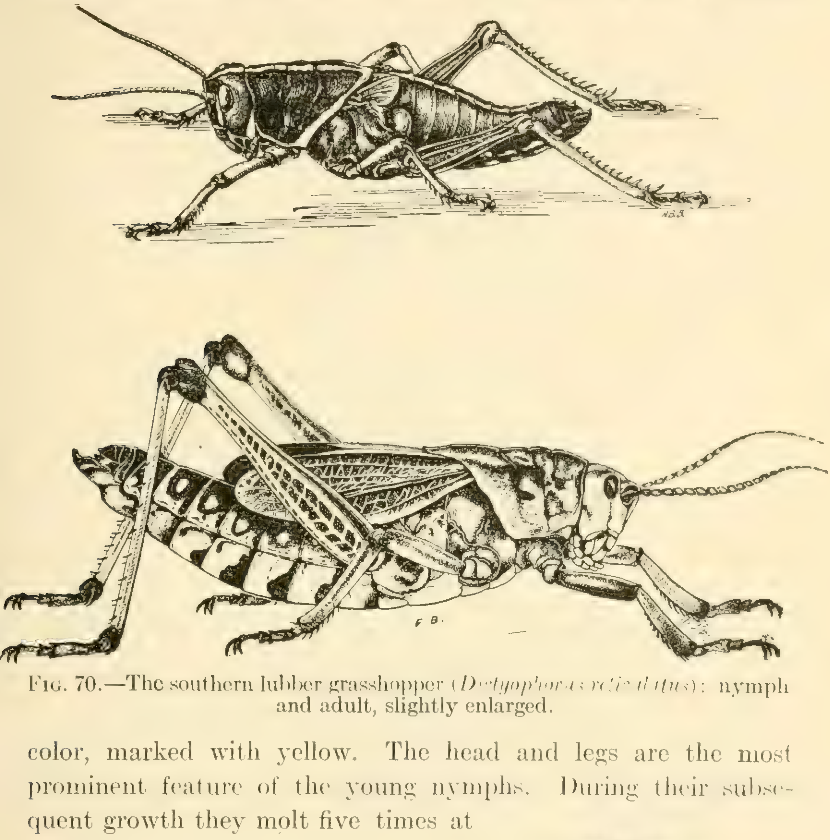


FIG. 70.—The southern lubber grasshopper (*Dictyophorus reticulatus*): nymph and adult, slightly enlarged.

color, marked with yellow. The head and legs are the most prominent feature of the young nymphs. During their subsequent growth they molt five times at intervals of ten days to two weeks, the relative size and appearance of the different stages being shown in Fig. 72. Professor H. A. Morgan, who made a careful study of an outbreak of this species in Mississippi in 1900, has given an interesting account of their growth and habits.

FIG. 71.—Egg-mass of the differential locust—enlarged.

"The young on first emerging from the eggs are sordid white and after an airing of an hour or two, are darker, assuming

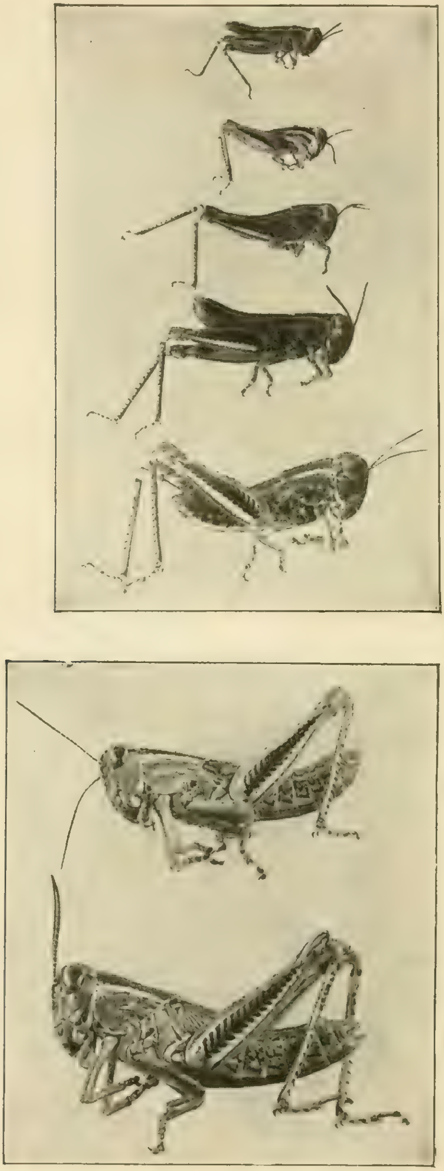


Fig. 72.—Nymphs of the differential locust in different stages (1 to 5) of growth—all enlarged.

a color not unlike the dark-gray alluvial soil over which they feed. There are changes of color as the earlier stages are assumed, but until the close of the third stage these changes are not readily perceptible in the field to the naked eye. At the close of stage four the greenish yellow color becomes prominent on many forms, and in stage five the greenish yellow and yellow brown colors predominate. The vigorous feeding and rapid growth of the young in stages four and five, and the prominence of the wing-pads in stage five, cause the grasshoppers in these conditions to appear almost as conspicuous as adults.

"The habits of the young are interesting, and a knowledge of some of them may be helpful in developing remedies. After hatching they remain for several hours in close proximity to the egg-pod from which they emerged. With this period of faint-heartedness over, they may venture out for a few yards each day into the grass, weeds, or crop neighboring the egg-area. Upon being disturbed they invariably make the effort to hop in the direction of the so-called nest. Nymphs emerging from eggs on a ditch bank, if forced into the water, will seldom make the effort to reach the other side, but will turn back to the bank from which they were driven. As development takes place the extent of their peregrinations into the crop is easily traced by the shot-hole appearance of the leaves upon which they feed. The tender leaves of cocklebur are always preferred by the grasshoppers in the early stages. Young Bermuda grass is also a favorite food, and succulent grasses of all kinds are freely eaten. In the third, fourth, and fifth stages, as grass, weeds, and even shrubs disappear along the ditch banks and bayous, the crops of corn and cotton adjacent begin to show signs of vigorous attack, and the march of destruction commences. . . . A few hours before molting the grasshoppers tend to congregate and become sluggish. Molting varies as to time, and slightly as to manner, with different stages. In the early stages less time is required and the operation occurs on the ground or upon low bunches of grass and weeds. Every effort of the grasshoppers at this time seems to be to avoid conspicuity, and in

doing so spare themselves, in a manner, enmity of parasites. After the molting of the first, second, and third stages it is not long before the young grasshoppers are sufficiently hardened to begin feeding again, but after the molt of the fourth and fifth stages, particularly the last molt, some time is required to extend the wings and dry and harden the body before feeding is resumed. The last molt usually occurs on the upper and well-exposed leaves of corn and other plants upon which they may be feeding, though it is not uncommon for the grasshoppers to drop to the ground during the maneuvers of the process. The reason for the selection of the more exposed leaves for the last molt is obvious. The bodies are large, and rapid drying protects them from fungous diseases which lurk in the more shaded and moist sections during the months of June and July. The last prominent habit to which we call attention is that of the fully grown grasshoppers to seek the shade offered by the growing plants during the hottest part of the day."

Fig. 73.—Differential locust: last stage of nymph with its cast skin on tip of corn plant.

The hoppers become full grown about the first of July. The adult is about $1\frac{1}{2}$ inches long, its wings expand $2\frac{1}{2}$ inches, and it is of a bright yellowish-green color. The head and thorax are olive-brown, and the front wings are of much the same color, without other markings, but with a brownish shade at the base;

the hind-wings are tinged with green; the hind-thighs are bright yellow, especially below, with four black marks; the hind-shanks are yellow with black spines and a ring of the same color near the base. The adults at once attack whatever crops are available, often finishing the destruction of those injured by them as nymphs, but in a few days their appetites seem to become somewhat appeased and they commence to mate and wander in search of suitable places for laying the eggs. Relatively few eggs are laid in cultivated ground, the favorite places being neglected fields grown up in grass and weeds, the edges of cultivated fields, private roadways, banks of ditches and small streams, and pasture lands. Alfalfa land is a favorite place for oviposition, and alfalfa is frequently seriously injured by this species. It is doubtless due these egg-laying habits and the abundance of food on uncultivated land that this species always increases enormously on land which has been flooded and then lies idle for a year or two. Most of the eggs are laid in August and early September. Each female deposits a single egg mass of about 100 eggs just beneath the surface of the soil. During this season the females may frequently be found with the abdomens thrust deep in the soil, as the process of egg-laying requires some time. The eggs are yellow and arranged irregularly in a mass which is coated with a gluey substance to which the earth adheres, which protects them from variable conditions of moisture and temperature.

Enemies.—As before mentioned, large numbers of the nymphs are destroyed before reaching maturity by their natural enemies. Among these a minute fungus undoubtedly kills many of those already somewhat exhausted, especially during damp weather. Almost all of our common birds, as well as many of the smaller mammals, are known to feed quite largely upon them.

A small red mite (*Trombidium locustarum* Riley), somewhat resembling the common red spider infesting greenhouses, is often of great value not only in killing the nymphs by great numbers of them sucking out the life-juices of the young hopper, but also in greedily feeding upon the eggs.

The maggots of several species of Tachina-flies are of considerable value in parasitizing both nymphs and adult locusts. Their eggs are laid on the neck of a locust, and, upon hatching,

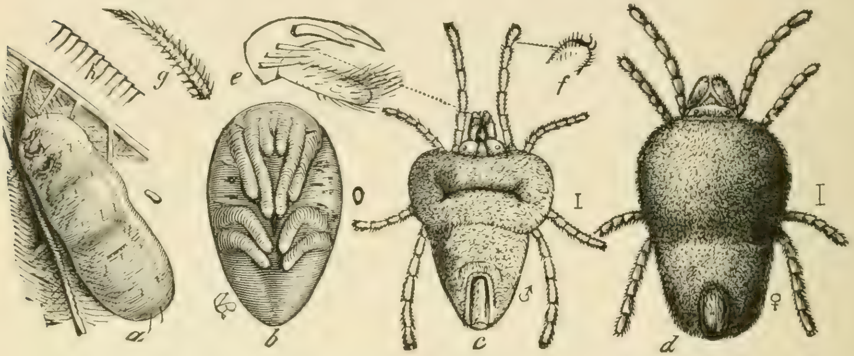


FIG. 74.—A Locust-mite (*Trombidium locustarum*): *a*, the larva as seen on locust's wing; *c*, male mite; *d*, female, the two latter appearing as when egg-destroyers—all greatly enlarged. (After Riley.)

the maggots pierce the skin and live inside by absorbing its juices and tissues. When full grown the maggots leave the locust, descend into the earth, and there transform to pupæ

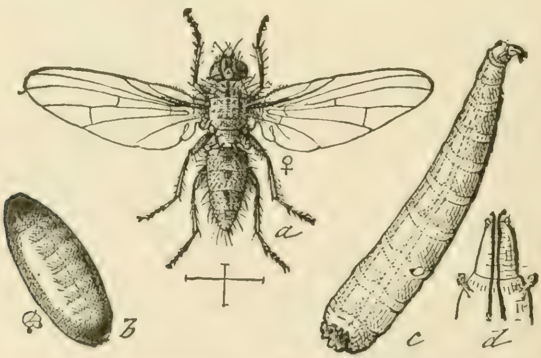


FIG. 75. *Anthomyia* egg-parasite. *a*, fly; *b*, puparium; *c*, larva; *d*, head of larva. (After Riley.)

inside of their cast skins, and from the pupæ the adult flies emerge in due time.

The maggots of one of the Bee-flies (*Systæchus oreas*) feed upon grasshopper eggs, but their life history is not fully known.

The common Flesh-fly (*Sarcophaga carnaria* Linn.), Fig. 77, is also very destructive, though largely a scavenger.

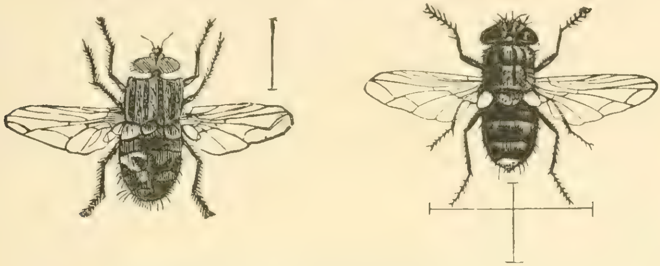


Fig. 76.—Two tachina-flies. (*Exorista leucaniæ* Kirk. and *E. flavicauda* Riley). (After Riley.)

But of all the insects attacking locusts, the Blister-beetles, which, unfortunately, are often known to us as very injurious to various garden crops, are probably of the most value. The female beetle deposits from four to five hundred of her yellowish eggs in irregular masses in loose ground, and in about ten days there hatch from these eggs some "very active, long-legged larvæ, with huge heads and strong jaws, which run about everywhere seeking the eggs of locusts." Each of these larvæ will consume one of the masses or about

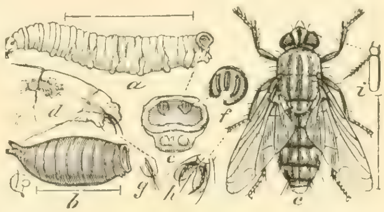


Fig. 77.—Common flesh-fly (*Sarcophaga carnaria* Linn.): *a*, larva; *b*, pupa; *c*, fly. Hair-lines show natural size. (After Riley.)

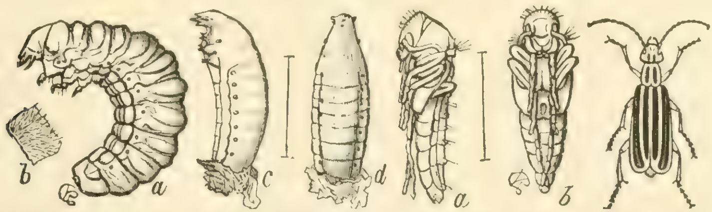


Fig. 78.—Various stages of a blister-beetle (*Epicauta vittata*). (After Riley.)

thirty eggs. The subsequent life history of these insects is very complicated on account of their peculiar habits, but the various stages are shown in Fig. 78.

Control.—As the eggs are usually laid in the ground in the fall, deep plowing in late fall or early spring effectually buries them too deep for the young nymphs to emerge. On alfalfa land thorough disking is often used for the same purpose. Thorough harrowing in the fall so as to pulverize the soil for the depth of an inch will break up many of the egg masses, though it is not as sure a control as plowing them under.

When the young emerge, they may sometimes be destroyed by burning over stubble, grass and rubbish where it is present in sufficient quantites, or by augmenting it with straw, which may be done to advantage on cold days when the nymphs are congregated in such shelter. If the surface of the ground is smooth and hard many may be killed by the use of a heavy roller, particularly in the morning and evening, when they are sluggish in their movements. Plowing a badly infested field in a square, working toward the centre so as to drive the young nymphs inward, will result in burying many of them in the furrows, and the last may be burned or trapped in holes as described below. Simple ditches 2 feet wide and 2 feet deep form effectual barriers for the young hoppers. The sides next to the crop to be protected should be kept finely pulverized by hauling a log or a brush of dead branches through the ditch. The ditch may be made as described for chinch-bugs and is handled in the same manner, the little hoppers drifting to the bottom of the ditch, where they are killed by the heat on a hot day or where they are caught in post-holes sunk every few feet in the bottom of the ditch. This method may be used to advantage in plots of corn, cotton, or garden truck which has already become infested, by running furrows around the field and occasionally through it, and then driving the young hoppers toward them, which may be readily done by a number of children armed with branches. Where ditches containing water are available the young hoppers may be very effectively destroyed by oiling the surface of the water with kerosene emulsion (p. 48) and then driving them into the ditches, for even if they succeed in crawling out they will succumb to the oil.

Where the young hoppers have congregated in large numbers on the edge of fields, in patches of weeds, etc., they may be destroyed by spraying them with kerosene or crude petroleum either pure or, preferably, in an emulsion, and the weeds and

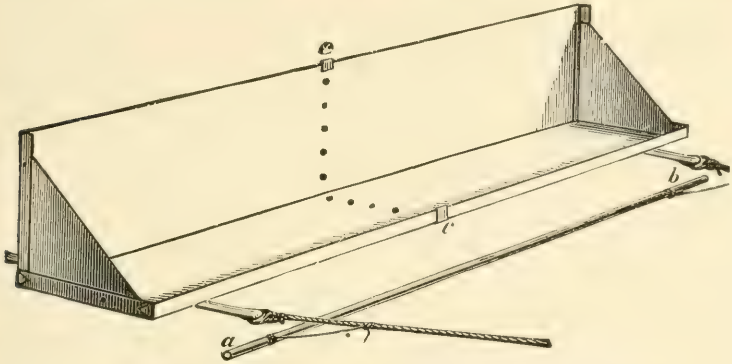


FIG. 79.—Simple coal-oil pan or hopperdozer. (After Riley.)

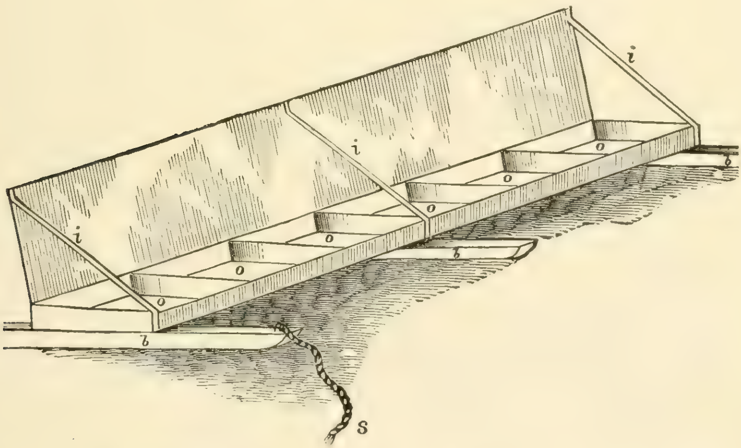


FIG. 80.—The Price oil-pan or hopperdozer, with partitions to prevent slopping. (After Riley.)

grass along fences and in neglected fields should be thoroughly treated with a strong arsenical spray or dust.

In pastures, small grains or any crops permitting their use, immense numbers of the nymphs may be caught by the use

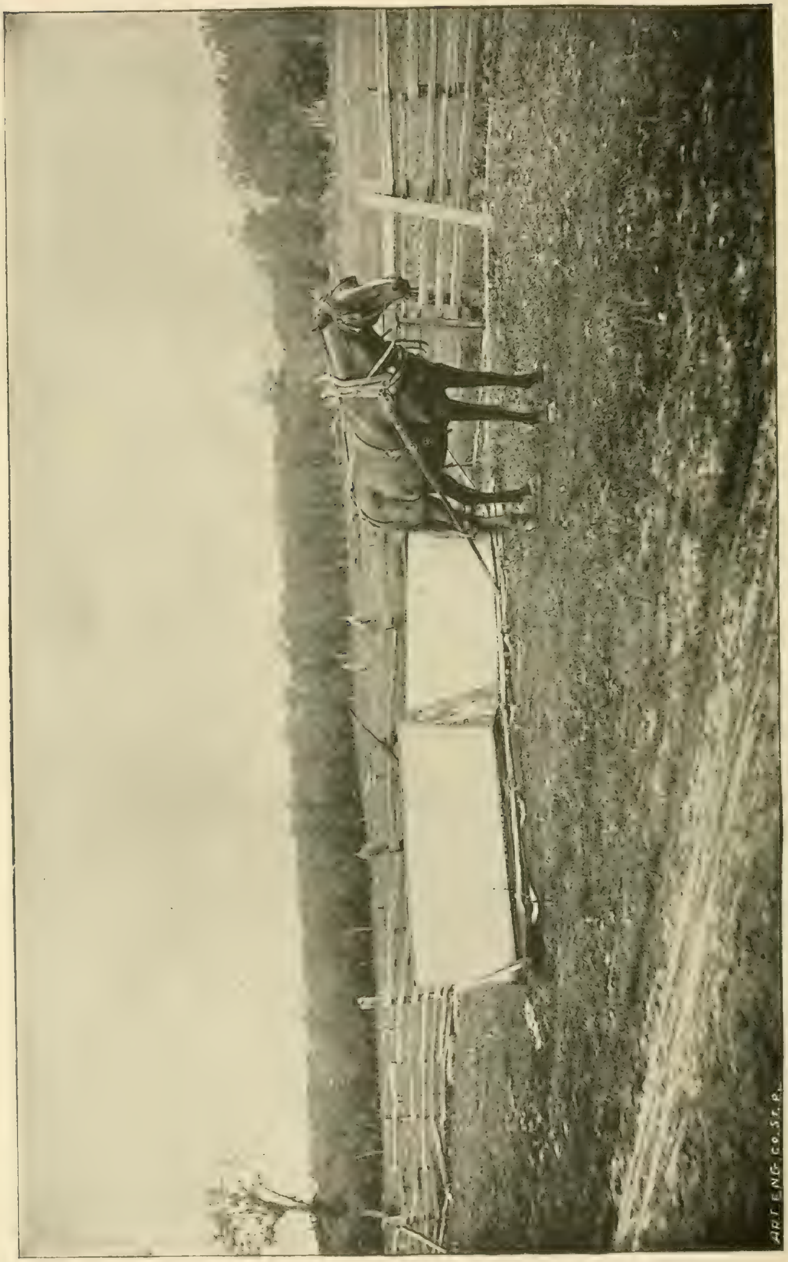


FIG. 81.—Two hopperdozers, tied together, at work. (After Lugger, Bull. 43, Minn. Agr. Exp. Sta.)

of hopperdozers, which may be utilized where the use of poisoned bran would not be possible. The hopperdozer consists of a shallow pan containing water with a surface of kerosene, crude petroleum, or coal tar, which is sometimes used without water. The pan is mounted on runners or wheels and if larger than about 3 feet square is usually provided with partitions to prevent slopping. The back and sides are high and sometimes are made of canvas. "A good cheap pan is made of ordinary sheet iron, 8 feet long, 11 inches wide at the bottom, and turned

FIG. 82.—Carolina locust killed by fungous disease. (Photo by Weed.)

up a foot high at the back and an inch high in front. A runner at each end, extending some distance behind, and a cord attached to each front corner, complete the pan at a cost of about $1.50 (Fig. 80). We have known of from seven to ten bushels of young locusts caught with one such pan in an afternoon. It is easily pulled by two boys, and by running several together in a row, one boy to each rope, and one to each contiguous pair, the best work is performed with the

least labor." Larger pans are drawn or pushed by horses. The oil is best used on the surface of water, from which the insects are removed with a strainer, and any which hop out will die after having come in contact with the oil.

Destroying the Adults.—The destruction of the winged insects is an entirely hopeless task, for, though even large numbers are caught, so many will remain that the damage done the crops would be but very slightly diminished. One of the most promising means for averting the swarms of winged migratory locusts from alighting in the fields is by a dense smudge, in which some foul-smelling substances are placed. Where strictly attended, and with favorable winds, this has often proved highly successful. To accomplish the best results farmers over an extensive area should combine in its use.

The South African Fungus.—In 1900 Professor Morgan made a test of a fungous disease which had been found to destroy large numbers of grasshoppers in South Africa, to determine whether, after starting it by artificial propagation, it would spread sufficiently to destroy any considerable number of locusts. The weather was favorable, rains being frequent. Early in August it was found that "over the areas where the liquid infection was spread diseased hoppers were abundant." "As many as a dozen dead grasshoppers could be found upon a single plant, and some upon nearly every weed on ditch-banks where grasshoppers were numerous. From the centres of infection great areas had become inoculated, spreading even beyond the plantations first infected." The property upon which it was placed became thoroughly infected with the fungus. Strangely, though many other species of grasshoppers were abundant, only the differential locust was killed by it. Dr. Howard states that this disease has also spread and done effective work in Colorado. However, more recent experiments made by the writer in Texas gave only negative results, and it is doubtful if any reliance can be placed upon the artificial use of such fungous diseases for locust control.

Poisoning.—A mash composed of bran, molasses, water, and

arsenic or Paris green, which has been extensively used for cutworms, was found to be quite successful in the experiments of Mr. D. W. Coquillet in the San Joaquin Valley, California, during 1885, for protecting orchards, vineyards, gardens, etc., and might even be of some value for grain crops. Two pounds of Paris green, 25 pounds of bran, barely moistened with water and cheap molasses, will be about the correct proportion. It should be placed in the fields, a tablespoonful to each plant or vine. At this rate the cost per acre of vineyard, including labor, will not exceed fifty cents. The poison acts slowly, but if judiciously used will be found very effective, especially for the non-migratory forms. In Texas the mash has been found satisfactory in destroying the grasshoppers attacking cotton. One planter writes: "We are successfully using arsenic (for grasshoppers) at the following rates: 10 pounds of wheat bran, 1½ gallons sorghum molasses, 1 pound arsenic. Make a thick mash, sow broadcast on infected ground, and it will surely kill them. I used 40 pounds last year and made 49 bales of cotton. My neighbors did not do anything and entirely lost their crop." The writer has also seen excellent results from the use of the mash in Texas with only one pound of poison to 25 pounds of bran. However, Professor Morgan concluded that "the mash cannot be relied upon in severe outbreaks, such as occurred in the delta, but may be used in limited attacks where the area affected would not warrant the more aggressive methods."

"When grasshoppers are young or half-grown, a poisonous bait, known as the Griddle Mixture, has proved effective in many parts of the country (particularly for the Rocky Mountain locust). This consists of one part of Paris green and about one hundred parts of fresh horse manure, by measure. Enough water is added to make the mass soft without being sloppy. It can be taken to the field by a wagon or stone boat and scattered about by means of a paddle."—Washburn.

The Army Worm*

Almost every year some locality reports serious injury to crops by armies of caterpillars, which have not been previously known for many years. This being the case the farmers are at a loss to combat them, and by the time information has been secured the pests have completed the damage. The Army Worm occurs throughout the United States east of the Rocky Mountains and lives in low, rank growths of grass, which form the normal breeding-grounds. When from an abundance of such food, or through failure of the parasites to prevent their increase, the caterpillars become overabundant, they assume the army habit and march en masse, consuming all in their path.

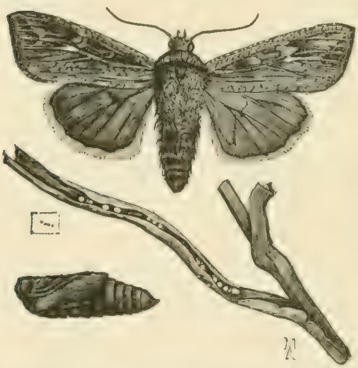


FIG. 83.—Army-worm moth (*Leucania unipuncta*), pupa, and eggs in natural position in a grass-leaf. Natural size. (After Comstock.)

The next year their natural enemies will usually have them under control again and there will be but little damage, and then they will not be observed as injurious for a series of years, though the moths are always fairly common.

Life History.—In the North the moths appear early in June and the females lay the small yellowish eggs in rows of from ten to fifty in the unfolded bases of the grass leaves, covering them with a thin layer of glue. Over seven hundred may be deposited by one female, so that when the young caterpillars hatch in about ten days, the progeny of a few moths might form a quite destructive army. The worms usually feed entirely at night, and thus whole fields will sometimes be ruined before they are discovered, though a few generally feed by day, as they all do in cloudy weather. The leaves and stalks of grains

* *Leucania unipuncta* Haworth. Family *Noctuidæ*.

FIG. 84.—Army worms at work on corn-plant. (After Slingerland.)

and grasses form their favorite food, the heads usually being cut off, but various garden crops are often seriously injured if they happen in their path. Though usually untouched, even clover is not exempt. In from three to four weeks the worms have become full grown and are then about $1\frac{1}{2}$ to 2 inches long, of a dark gray or dingy black color, with three narrow, yellowish stripes above, and a slightly broader and darker one on each side, quite resembling cutworms, to which they are nearly related. They now enter the earth and transform to pupæ, from which the adult moths emerge in about two weeks. These lay eggs for another brood of worms which appear in September, but are very rarely injurious. The moths which develop from this last brood either hibernate over winter, or deposit eggs, the larvæ from which become partially grown before cold weather and then hibernate. In either case the young larvæ feed in the spring, not usually doing much damage, pupate in May, and the moths of the first generation appear in June as already described. Thus in the North there are three broods a year, the young larvæ usually hibernating, while in the South there may be as many as six generations, and the moths usually hibernate over winter and lay their eggs in the spring.

FIG. 85.—An army worm—about one-third enlarged. (After Chittenden, U.S. Dept. Agr.)

FIG. 86.—*a*, head of fall army worm; *b*, head of army worm—enlarged. (After Chittenden, U.S. Dept. Agr.)

The moths very often fly into lights and are among the commonest of our plain "millers." The front wings are a clay or fawn color, specked with black scales, marked with a darker shade or stripe at the tips, and with a distinct spot at the centre,

which gives the specific name *unipuncta*. The hind-wings are somewhat lighter with blackish veins and darker margins.

Enemies.—Were it not for other insects which prey upon the army worm, the army habit would doubtless be more often assumed and we should have to deal with them more frequently. Ordinarily, however, the parasitic and predaceous insects hold them in check very efficiently and when an outbreak does occur, the later broods of the same season are often entirely destroyed by their insect enemies. Large numbers are always destroyed by the

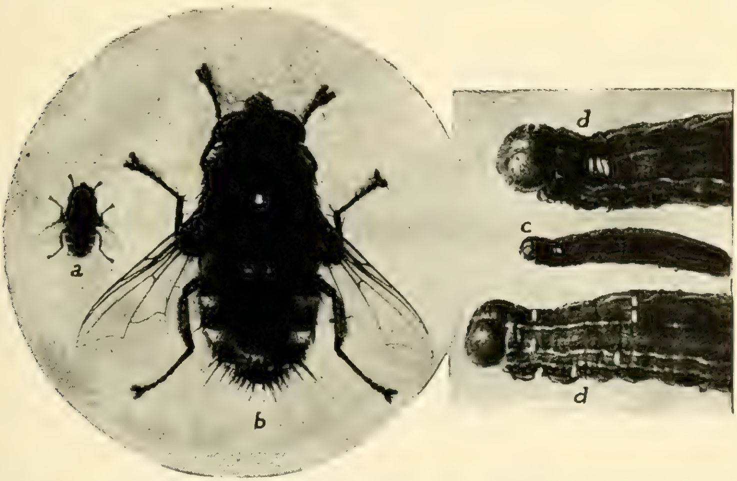


Fig. 87.—The farmer's friend, the red-tailed tachina-fly (*Winthemia 4-pustulata*): *a*, natural size; *b*, much enlarged; *c*, army worm on which fly has laid eggs, natural size; *d*, same, much enlarged. (After Slingerland.)

predaceous ground-beetles and their larvæ (p. 14), but their most deadly enemies are the tachina-flies (p. 106). These lay from a dozen to fifty eggs on a caterpillar, and the maggots from them enter the body and absorb the juices and tissues of the host, thus soon killing it. When feeding at night the worms are ordinarily free from these parasites, but when the marching habit is assumed the flies swarm around them on cloudy days and before the next year they again have the remnants of the voracious army under subjection. Therefore, worms with the

tachina-fly eggs on them (Fig. 87) should never be destroyed where avoidable.

Control.—When detected, all efforts should be centred on keeping the worms out of crops not yet attacked and confining their injury to as small an area as possible. As a barrier to their progress, there is nothing better than a dust furrow made as already described for chinch-bugs (p. 91), two or three of which may be found necessary in cool weather or where a fine dust cannot be maintained.

Deep fall plowing and thorough harrowing will be effective against the hibernating larvæ, as will the burning of all grass along ditches, fences, and spots where the larvæ normally live.

By thorough spraying, or perhaps better by dusting, a strip of the crop with Paris green or some arsenical, and liberally distributing poisoned bran mash (see p. 47), large numbers may be destroyed. Where they are massed in furrows they may be destroyed by spraying them with pure kerosene or crude petroleum.

As in fighting chinch-bugs the army worm must be given immediate and conclusive combat if the loss of crops is to be prevented, for they move rapidly and destroy all in their path.

The Fall Army Worm *

Though somewhat the same in its habits as the true army worm, the Fall Army Worm is so called because it appears later in the season, the former species being rarely injurious after August 1st. It is also more omnivorous, for while the army worm prefers grasses, and grains, the fall army worm feeds upon a large variety of crops, including sugar-beets, cow-peas, millet, sweet potatoes, and many other forage and truck crops. In Nebraska and the Central West it is a serious pest of alfalfa and is called the Alfalfa Worm. It is also sometimes very destructive to lawns, as was the case in Chicago in 1899. The fall army worm is more of a native of the Southern States, but occurs from Canada to the Gulf and west to the Rockies.

* *Laphygma frugiperda* S. and A. Family *Noctuidæ.*

At first glance the caterpillars have much the same general appearance as the army worm, but closer examination reveals marked differences. Along each side of the body is a longitudinal pitch-colored stripe, and along the middle is a yellowish-gray stripe about twice as wide, which includes four black dots on each segment. The caterpillars assume the habit of working in armies, but usually do not feed in such large numbers as the true army worms and thus are more difficult to combat.

Life History.—The winter is passed in the pupal state, the pupæ being about one-half inch long and being found in cells one-quarter to one-half an inch below the surface. The moths emerge in the spring and the females lay their eggs on grass in clusters of fifty or more, each mass being covered with the mouse-colored hairs from the body of the female. The eggs hatch in about ten days and the caterpillars are found during May and June. The complete life history of the insect has not been carefully followed, but it seems probable that there are but two complete generations in the North, three generations in the latitude of central and southern Illinois and the District of Columbia, and four in the extreme South. In any event, the destructive brood of caterpillars appears in August and early September.

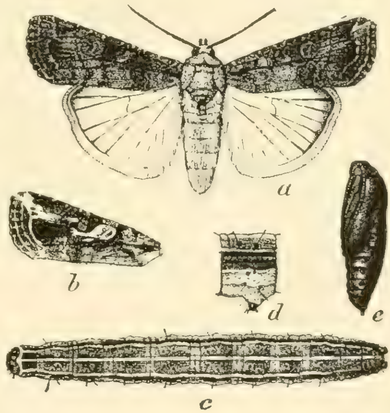


FIG. 88.—The fall army-worm: *a*, moth, plain gray form; *b*, fore wing of Prodenia-like form; *c*, larva extended; *d*, abdominal segment of larva, side view; *e*, pupa; *d*, twice natural size, others enlarged one-fourth. (After Chittenden, U. S. Dept. Agr.)

The parent moth is of a " general yellowish, ash-gray color, with the second pair of wings almost transparent, but with a purplish reflection. In extent of wings it measures about $1\frac{1}{4}$

inches, and when closed the length of the insect is about three-quarters of an inch. The front wings are mottled or marbled, especially near the central area, and usually there is visible a fine white line a short distance from the edge and parallel to it. The hind-wings have a fringe of darker hair as well as veins that contrast somewhat with the lighter portion" (Fig. 88).

Control.—Deep fall plowing and thorough harrowing will break up the pupal cells and thus largely prevent the development of the spring brood of moths. In perennial crops like alfalfa thorough disking may be used and on lawns deep raking with a long-toothed steel rake will kill many of the pupæ. In fields of young grain and on lawns many of the caterpillars may be killed by a heavy roller. When not present in too large numbers, the worms may be destroyed by spraying the food plants with Paris green, arsenate of lead or other arsenicals, or by the use of poisoned bran mash. When present in large numbers and the army habit is assumed they should be combated the same as the army worm.

CHAPTER VIII

INSECTS INJURIOUS TO SMALL GRAINS *

Meadow-maggots or Leather-jackets †

SEVERAL instances have been recorded in which serious injury has been done to wheat, clover, timothy, and blue grass by the larvæ of Crane-flies. These insects are never so injurious in this country as in Europe, where they are known as "daddy-long-legs," the common name of our harvest-spiders, though doubtless injury done by them is often attributed to other insects. The farmer usually declares the work to be that of wireworms or cutworms, the adults often being known as "cutworm-flies," unless the maggots are so abundant as to attract his attention. When the maggots are abundant enough to do much injury, they usually occur in very large numbers, but ordinarily, though common everywhere, they are not numerous enough to attract attention.

Several species (*Tipula bicornis* Loew, *T. costalis* Say, and *Pachyrrhinis* sp.?) have at various times done considerable damage in localities in Ohio, Indiana, Illinois, and elsewhere.

Life History.—So far as studied, the life histories of these species seem to be much the same. The larvæ remain dormant over winter, but evidently commence feeding again very early in the spring, a wheat-field having shown the effects of their injuries from February 1st to April 1st. The larvæ become full grown from the latter part of April until the middle of May, depending upon the species and season. The full-grown maggots are about an inch long, of a dirty-grayish color, and of a tough,

* See "The Principal Insect Enemies of Growing Wheat," C. L. Marlatt, Farmers' Bulletin No. 132, U. S. Department of Agriculture.

† Family *Tipulidæ*.

leathery texture. They are nearly cylindrical, somewhat tapering in front and terminating bluntly behind. Legs are entirely wanting, but at the blunt end are a few fleshy processes and a pair of small, horny hooks. The larvæ seem to prefer low, moist ground, and will live for some time on land entirely flooded or in a ditch. They feed very largely on dead vegetable matter, but when excessively abundant they attack the roots of wheat, grass, and clover, so weakening them near the surface that the plants, deprived of proper nourishment, are killed and loosened from the ground.

FIG. 89.—A Crane-fly (*Tipula hebes* Loew): male adult. (After Weed.)

Pupæ may be found during the latter part of May, occupying small cells in a vertical position near the surface of the soil. Prior to emerging the adult pushes from one-half to two-thirds of the body above the surface and remains in this pose for several hours. The males usually emerge first, as their assistance is required by the females, which are loaded down with eggs, to extricate themselves from the pupal skins. The sexes pair immediately, there being many more males than females—one observer states one hundred to one—and the females deposit their eggs upon grass

and clover lands, to the number of three hundred each. Eggs are laid for another brood in September, the maggots from which live over winter.

Remedies.—Injury to wheat-land may be largely prevented by plowing early in September.

No satisfactory remedy for the maggots is known when injuring clover, timothy, or grass, although large numbers have been destroyed by driving a flock of sheep over infested land. Dr. S. A. Forbes states that "close trampling of the earth by the slow passage of a drove of pigs would doubtless answer the same purpose, which is that of destroying the larvæ lying free upon the surface or barely embedded among the roots of the grass."

Several of our common birds as well as a number of ground-beetles feed upon the maggots and flies. The maggots are also sometimes attacked by a fungous disease which in the damp soil in which they live doubtless grows and spreads rapidly. Altogether these different enemies keep them so well in check that they rarely become of importance.

The Hessian Fly *

The Hessian fly is much the most destructive of any of the insects attacking wheat, to which its injury is practically confined; for though it occasionally injures barley and rye, it has never been reared on other grains or grasses. Its name was received from the fact that it was first noticed on Long Island in 1779, near where the Hessian troops had landed three years before. It now occurs over the main wheat-growing area of the eastern United States between parallels 35° and 45° westward to the 100th meridian, on the Pacific coast, in Canada, and in many other parts of the world where wheat is grown. Not infrequently it destroys 25 to 50 per cent of the whole crop in some localities, and it has been estimated that 10 per cent of the crop of the whole country is lost from its ravages.

Life History.—The adult flies are little dark-colored gnats about

* *Mayetiola destructor* Say. Family *Cecidomyidæ.*

one-tenth inch long, so small as to commonly escape observation. Each female lays 100 to 150 minute reddish eggs, one-fifteenth inch long, placing them in irregular rows of from three to five or more, usually upon the upper surface of the leaves. In a few days these hatch into small, reddish maggots, which soon turn white, are cylindrical, about twice as long as broad and have no true head or legs. The fall brood of maggots burrow beneath the sheaf of the leaf and its base, causing a slight enlargment at the point of

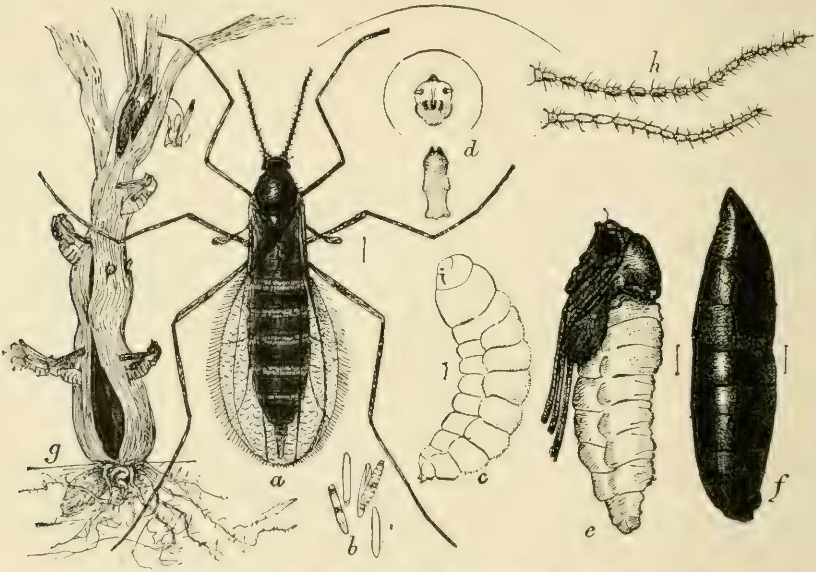


Fig. 90.—The Hessian fly (*Mayetiola destructor*): *a*, female fly; *b*, flaxseed stage or pupa; *c*, larva; *d*, head and breast-bone of same; *e*, pupa; *f*, puparium; *g*, infested wheat-stem showing emergence of pupæ and adults. (After Marlatt,, U. S. Dept. Agr.)

attack; but in the spring they usually stop at one of the lower joints, in both instances becoming fixed in the plant, absorbing its sap and destroying the tissues. The first indications of the work of the maggots on winter wheat in the fall are the tendency of the plants to stool out, the dark color of the leaves, and the absence of the central stems. Later many of the plants yellow and die. The spring maggots attack the laterals, or tillers, which have escaped the previous brood, so weakening them that the

stems break and fall before ripening and cannot be readily harvested.

About four weeks after hatching the maggots are full grown, and are greenish-white and about three-sixteenths inch long. The skin then turns brown, shrivels slightly, and inside it is formed the pupa. This outside case, composed of the cast larval skin, is known as the "puparium," and this stage is commonly called the "flaxseed" from the resemblance to that seed. In this stage most of the fall brood passes the winter, the flies emerging in April or May, while the summer brood remains in the "flaxseed" stage in the stubble during the late summer and emerges when the first wheat is planted in the fall, emerging later further south.

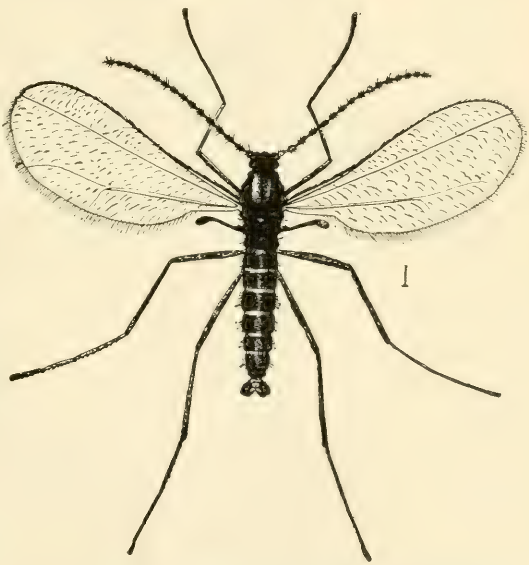


FIG. 91.—The Hessian fly, adult male—greatly enlarged. (After Marlatt, U. S. D. Agr.)

Several species of small chalcis flies (page 19) parasitize the larvæ and pupæ, and were it not for their assistance it would doubtless be difficult to raise wheat. As yet no practical method of increasing their abundance has been devised, though colonies have been carried to regions where they were scarce.

Control.—The principal means of avoiding injury by the Hessian fly in the winter wheat regions is late planting in the fall. Inasmuch as the flies appear within about a week and then disappear, if planting be delayed until after that time, but little of the wheat will be injured. Dry weather in late summer and early

fall will delay the appearance of the flies, even with normal temperature conditions, and the further south, the later they appear. From experiments being conducted by the U. S. Bureau of Entomology, Professor F. M. Webster states that the following dates will probably be found safe for sowing wheat in average seasons: in

FIG. 92.—"Flax-seeds" or puparia of the Hessian fly on young wheat—enlarged. (After Pettit.)

northern Michigan soon after the 1st of September; in southern Michigan and northern Ohio, about September 20th; in southern Ohio after the first week in October; in Kentucky and Tennessee, October 10th to 20th; in Georgia and South Carolina, October

25th to November 15th. The exact time will also depend upon altitude as well as latitude.

A rotation of the wheat crop compels the flies when they emerge from the stubble to travel in search of the young wheat plants. Should storms or heavy winds occur, the frail little flies will be destroyed in large numbers, whereas if they found wheat immediately available the mortality would be small.

Inasmuch as most of the spring brood remain in the stubble in the flaxseed stage after harvest, if the fields be then burned over, large numbers will be destroyed. This may be done by cut-

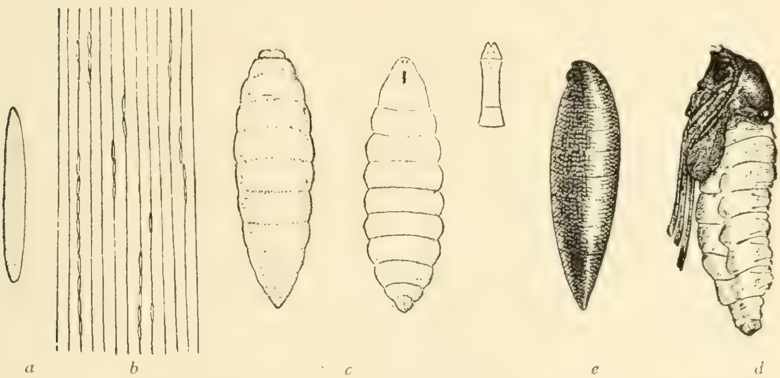


FIG. 93.—Hessian fly: *a*, egg, greatly enlarged; *b*, section of wheat-leaf showing eggs as usually deposited—less enlarged; *c*, larva; *d*, pupa taken from puparium or "flaxseed"—*e*; *c*, *d*, *e*, much enlarged. (After Webster and Marlatt, U. S. Dept. Agr.)

ting the grain rather high at harvest, and then mowing the weeds and grass and allowing them to dry a few days before burning. Unfortunately this practice is often impossible, owing to the practice of seeding wheat land to grass and clover.

As early volunteer plants always become badly infested and the pupæ wintering on them give rise to a spring brood which attacks the main crop, all volunteer plants should be destroyed by plowing or disking before the larvæ have matured. This principle has sometimes been utilized in the form of a trap crop, strips of wheat being sown early so as to attract the flies and then being plowed under

after the bulk of the eggs had been laid upon them, thus protecting the main crop, planted later.

The enrichment of the soil, the preparation of a good seed bed, and the use of good seed, so as to secure a vigorous growing crop, are all of the greatest importance in overcoming injury by the Hessian fly. After the crop is once attacked, no truly remedial measures are known except to apply liberally some quick-acting fertilizer which will cause the plants to tiller freely and give them sufficient vigor to withstand the winter and thus increase the healthy stems the next spring.

Though none are exempt from attack, those varieties of wheat " with large, coarse, strong straw are less liable to injury than weak-strawed and slow-growing varieties." * In New York in many localities in 1901 a wheat called Dawson's Golden Chaff was found to be but little injured, where others were nearly destroyed. However, in Canada, where this variety originated, it is as seriously injured as other kinds, and may become so in New York. Bearded Red Wheat No. 8 was also found to be a very resistant variety, as were Prosperity, Democrat, Red Russian, and White Chaff Mediterranean. It should be remembered, however, that none of these are invariably " fly-proof," and that though under certain conditions they may be but little injured, in other localities and under less favorable circumstances they may be injured as much as any other sorts.

Among other conclusions Professor Roberts* and his colleagues state that the fly " injures wheat more on dryish and poor land than on moist but well-drained, rich soils." Also, " that the soil must be so well fitted and so fertile that a strong, healthy growth will be secured in the fall, though the sowing of the seed be delayed ten to fifteen days beyond the usual time. Such preparation of the soil will also help the wheat to recover from any winter injury. Thick seeding and vigorous growth also tend to ward off the fly." " Much stress should be laid on the proper fitting of the land for wheat. Plowing should be done early—at least six weeks before

* Cornell University Agr. Exp. Sta., Bulletin 194: The Hessian Fly, I. P. Roberts, M. V. Slingerland, and J. L. Stone.

sowing—to give abundant time for the repeated working of the soil in order to recompact the subsurface soil and secure a fine but shallow seed-bed in which there has been developed, by tillage and the action of the atmosphere, an abundance of readily available plant food. Manures and fertilizers should be kept near the surface and the young roots encouraged to spread out on the surface soil, thus avoiding much of the damage by heaving in winter and leaving the deeper soil for fresh pasturage for the plants during the following spring and summer."

In summarizing his knowledge of means of controlling this pest, Professor F. M. Webster, who is probably our best authority upon it ,says: "After thirteen years of study of the Hessian fly, I am satisfied that *four-fifths of its injuries may be prevented by a better system of agriculture.* For years I have seen wheat grown on one side of a division-fence without the loss of a bushel by attack of this pest, while on the other side the crop was invariably always more or less injured. No effect of climate, meteorological conditions, or natural enemies could have brought about such a contrast of results. The whole secret was in the management of the soil and the seeding."

The Wheat Saw-fly Borer *

The "Corn Saw-fly" has for many years been a well-known wheat pest throughout England, France, and the Continent, but was not noted as injurious in this country till 1889, when Professor J. H. Comstock published a very complete account of its injuries upon the University Farm at Ithaca, N. Y., where it had done more or less damage for two years, though Mr. F. H. Chittenden states that he collected a single adult at Ithaca in the early '80's. Specimens were also collected at Ottawa, Canada, and Buffalo, N. Y., in 1887 and 1888, and injury has been reported by Dr. James Fletcher from Manitoba and the Northwest Territories. The injury under Dr. Fletcher's observation, however, was probably due to a nearly related species, the Western

* *Cephus pygmæus* Linn. Family *Cephidæ*. Bulletin 11, Cornell Univ. Agr. Exp. Station.

Grass-stem Saw-fly (*Cephus occidentalis* Riley and Marlatt). This is a native species which normally lives in wild grasses and which has been quite injurious in certain sections of the Northwest during recent years. It habits and the means of control are practically identical with the species here discussed.†

The following is gleaned from Professor Comstock's interesting account.

Injury.—No external indications of injury to the plant can be seen until the larva within has almost completely tunneled the stalk, at which time there is a discoloration just below the injured joints. Thus damage by this insect is not readily noticed, it merely dwarfing and stunting the growth of the plant by boring in the stem.

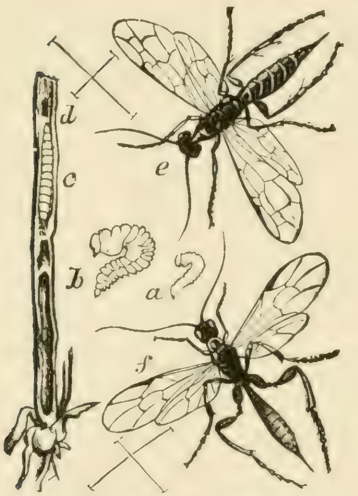


FIG. 94.—The wheat saw-fly borer (*Cephus pygmæus* Linn.): *a*, outline of larva, natural size; *b*, larva, enlarged; *c*, larva in wheat-stalk, natural size; *d*, frass; *e*, adult female; *f*, *Pachyonerus calcitrator*, female, a parasite — enlarged. (After Curtis, from "Insect Life.")

"If infested straws be examined a week or ten days before the ripening of the wheat, the cause of this injury can be found at work within them. It is at that time a yellowish, milky-white worm, varying in size from one-fifth to one-half an inch in length. The smaller ones may not have bored through a single joint; while the larger ones will have tunneled all of them, except, perhaps, the one next to the ground.

Life History.—"As the grain becomes ripe the larva works its way toward the ground; and at the time of harvest the greater number of them have penetrated the root. Here, in the lowest part of the cavity of the straw, they make preparations for passing the winter, and even for their escape from the straw the

† See F. M. Webster, Circular 117, Bureau of Entomology, U. S. Dept. Agr.

following year. This is done by cutting the straw circularly on the inside, nearly severing it a short distance, varying from one-half to one-inch, from the ground. If the wheat were growing wild, the winter winds would cause the stalk to break at this point; and thus the insect after it had reached the adult state could easily escape; while but for this cut it would be very liable to be imprisoned in the straw." Ordinarily, the straw is cut by the reaper before it becomes broken; but a strong wind

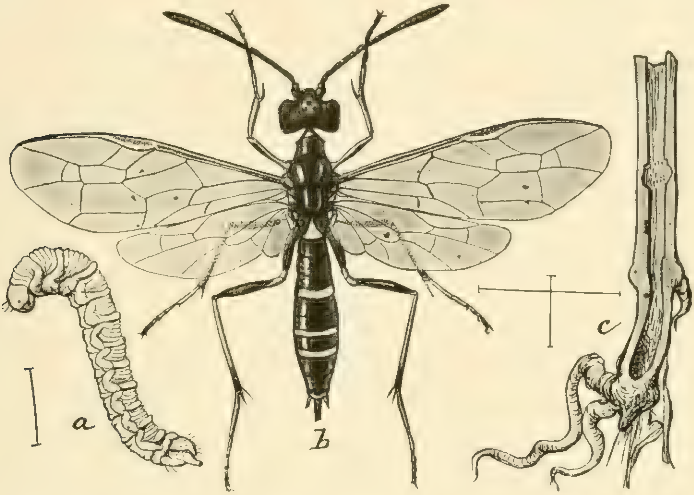


FIG. 95.—The western grass-stem saw-fly (*Cephus occidentalis*): *a*, larva; *b*, female saw-fly; *c*, grass-stem showing work. *c*, enlarged, *a*, *b*, more enlarged. (After Marlatt, U. S. Dept. Agr.)

just before harvest will cause a large number of stalks to become broken, much as if affected by the Hessian fly.

"After the circular cut has been made, the larva fills the cavity of the straw just below it for a short distance with a plug of borings. Between this plug and the lower end of the cavity of the straw there is a place about one-half an inch in length. It is here that the insect passes the winter." This cell is lined with silk so as to form a warm cocoon. Here the larva passes the winter and changes to a pupa in March or April. The adult insect emerges early in May. The adults are four-winged insects,

and are popularly known as saw-flies on account of the saw-like ovipositor of the female, by means of which she inserts her eggs in the tissue of the plant. This species is quite different in some respects from the saw-flies feeding upon the leaves of wheat, and belongs to the family *Cephidæ*.

The female commences to lay eggs by the middle of May. By means of her sharp ovipositor she makes a very small slit any place in the stalk of the plant and in this thrusts a small white egg—about $^1/_{100}$ of an inch long—which is pushed clear through the walls of the straw and left adhering to the inside. Though several eggs are deposited in a straw, but one larva usually develops. "The eggs hatch soon after they are laid, and the larvæ may develop quite rapidly. A larva which hatched from an egg laid May 13th was found to have tunneled the entire length of the stalk in which it was" on May 28th.

Remedies. "The most obvious method of combating the insect is to attack it while it is in the stubble; that is, sometime between harvest and the following May. If the stubble can be burned in the autumn, the larvæ in it can be destroyed. The same thing could be accomplished by plowing the stubble under, which would prevent the escape of the adult flies. But as it is (often) customary . . . to sow grass-seed with wheat, it is feared that the plowing under of infested stubble would rarely be practicable; and it is also questionable if the burning of the stubble could be thoroughly done without destroying the young grass. It would seem probable, therefore, that if this insect becomes a very serious pest, it will be necessary. . . either to sow grass-seed with oats and burn or plow under all the wheat stubble, or to suspend growing wheat for one year, in order to destroy the insects by starvation."

Some Wheat-maggots

Very similar to the Hessian fly in its mode of injuring the wheat-stalk is the Wheat-stem Maggot (*Meromyza americana* Fitch). The adult flies were first described by Dr. Fitch in 1856,

though the work of the maggots had probably been noticed as early as 1821 by James Worth of Bucks County, Pa., and by the *Michigan Farmer* in Michigan about 1845.

Extending from Dakota and Manitoba to Texas, the range of this insect practically covers all the eastern United States and southern Canada.

Unlike the Hessian fly it feeds and breeds upon wild grasses and is thus much more difficult to control. Prof. A. J. Cook found the larvæ in both barley and oats in Michigan, Prof. F. M. Webster reared an adult from blue grass (*Poa pratensis*), and Dr. Jas. Fletcher records it as breeding in *Agropyrum*, *Deschampsis*, *Elynius*, *Poa*, and *Setaria viridis* in Canada.

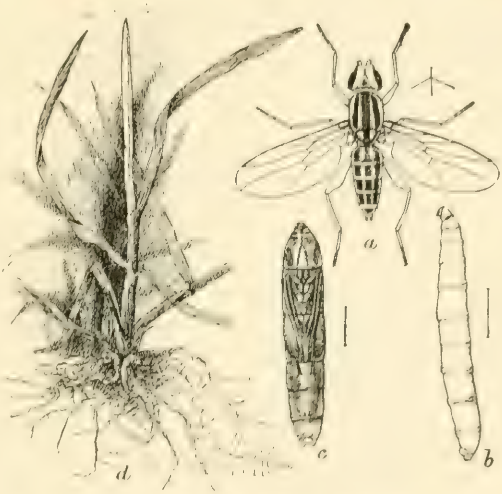


Fig. 96.—Wheat bulb-worm (*Meromyza americana*). *a*, mature fly; *b*, larva; *c*, puparium; *d*, infested wheat-stem—all enlarged except *d*. (After Marlatt, U. S. Dept. Agr.)

Life History.—Like the Hessian fly the adult flies lay their eggs on fall wheat in September and October, and the young maggots when hatched work their way down into the stem, either cutting it off or causing it to discolor or die. The eggs are about one-fortieth of an inch long and of a glistening white color. The larvæ are a light greenish color, about one-fourth of an inch long, tapering toward the terminal end while subcylindrical posteriorly, being quite elongate. The pupæ are the same color as the larvæ, but more rounded, being only one-sixth of an inch long, and reveal the legs and wing-cases of the imago forming within them. The

external case of the pupa, called the puparium, is merely the shrunken and hardened cast skin of the last larval stage, within which the insect transforms to the pupa. The fly is about one-fifth of an inch long. It is of a yellowish-white color with a black spot on the top of the head, three broad black stripes on the thorax, and three on the abdomen, which are often interrupted at the sutures, so that they form distinct spots. The eyes are a bright green.

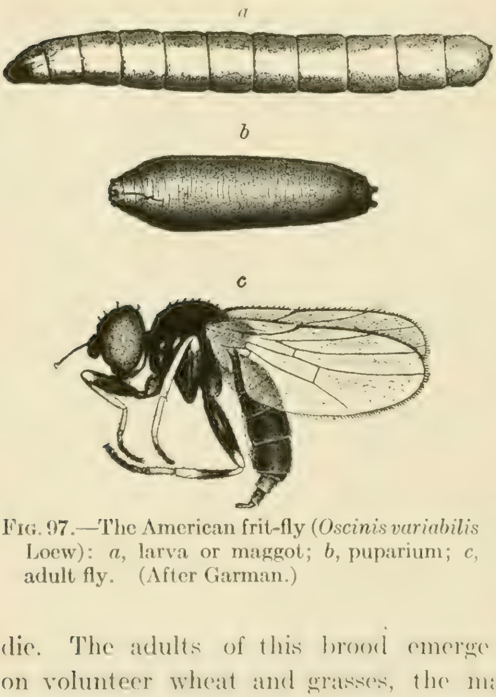


FIG. 97.—The American frit-fly (*Oscinis variabilis* Loew): *a*, larva or maggot; *b*, puparium; *c*, adult fly. (After Garman.)

The winter is passed by the larvæ in the young plants and in spring they transform to pupæ and adult flies. These in turn deposit eggs in such a position that the maggots issuing from them may readily feed upon the succulent portions of the growing stalk. Numerous larvæ thus sapping the life of the plant soon kill it outright or cause the top and head to wither and die. The adults of this brood emerge in July and lay eggs on volunteer wheat and grasses, the maggots working in the same manner as in the fall and coming to maturity so that another brood of flies lays eggs for the fall brood on the newly planted wheat.

Owing to the fact that this insect breeds also in grasses during late summer it is much more difficult to combat than were it confined to wheat as its food-plant, as is the Hessian fly.

Remedies.—"If the grain is stacked or threshed and the straw stacked or burned," says Professor Webster, "it is clear that

the number escaping would be greatly reduced," for, as the adults emerge soon after harvest, they would escape to deposit their eggs were the straw left in the fields, but "it is not likely that those in the centre of the stacks would be able to make their way out, and the threshing-machine would destroy many more. How much could be accomplished by late sowing of grain is uncertain, as the females are known to occur abundantly up to October. If plots of grain were sowed immediately after harvest in the vicinty of the stacks, many of the females could, no doubt, be induced to deposit their eggs therein, and these could be destroyed by plowing under." Burning of the stubble will also aid in keeping this pest under control.

There are several undetermined species of flies belonging to the genus *Oscinis*, which have practically the same life history as the wheat stem-maggot and injure the wheat in the same manner. They very closely resemble the common house-fly in miniature, being about one-fourth as large. They will not need consideration by the practical farmer other than in applying methods of control as already given. One species of this genus, determined by Professor H. Garman as *Oscinis variabilis* Loew and christened the American Frit-fly, has been found common in Kentucky and Canada, but in the larval stage is so nearly identical in appearance and habit with the stem-maggot that it can with difficulty be distinguished from it.

That these pests do not do more injury is probably due, to a considerable extent, to the fact that large numbers of them are destroyed by a small hymenopterous parasite, known as *Cœlinus meromyzæ* Forbes, which very commonly infests the larvæ, and by other parasites and predaceous insects.

Rarely will these pests do serious damage, but very often it is sufficient to merit consideration, and only a knowledge of their life history can give a key to their successful control.

The Wheat Joint-worm *

For the last sixty years the joint-worm has been known as a serious pest of wheat throughout the wheat-growing region east of the Mississippi River, the damage varying from a slight injury which is hardly noticeable, and which may escape observation for several years, to an almost total destruction of the crop.

The adults appear in April, May, or early June, according to the latitude, and are small black, four-winged flies about one-eighth inch long, with the joints of the legs and feet yellow. They look something like small, winged black ants (Fig. 99) and curiously enough belong to a family whose members are almost all parasitic on other insects, so that before they had been thoroughly studied they were thought to be parasites of the Hessian fly. The females lay their eggs in the stems, generally selecting the uppermost joints that have appeared at that time. "The young worms develop rapidly, each in a little cavity within the straw. Often knots, swellings, and twistings occur in the straw at the point of infestation; again there is little sign of the insect's presence except a slight discoloration or a little deviation of the fibres and grooves of the straw from their natural course. When the infested section is split with a knife it is found to be brittle and

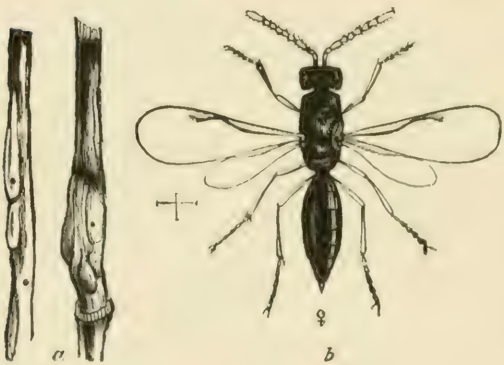


FIG. 98.—*a*, wheat-straw affected by joint-worm; *b*, adult as seen from above. (After Riley.)

* *Isosoma tritici* Fitch. Family *Chalcididæ*. See J. S. Houser, Bulletin 226, Ohio Agr. Exp. Sta.; and F. M. Webster, Circular 66, Bureau of Entomology, U. S. Dept. Agr.

woody in character, and contains from 3 or 4 to 20 or more yellowish larvæ, about one-eighth inch long when full-grown. These larvæ remain in the straw until the following spring, when they issue as adults and commence again the life cycle in the new crop. The damage is done by the worms cutting off the sap supply from the head, causing it to become shortened, containing comparatively few kernels, and such kernels as develop are apt to be small and shriveled from lack of nourishment. Also because of the brittleness of the straw high winds are apt to break much of it down."—Gossard.

The presence of the pest is always indicated at threshing by

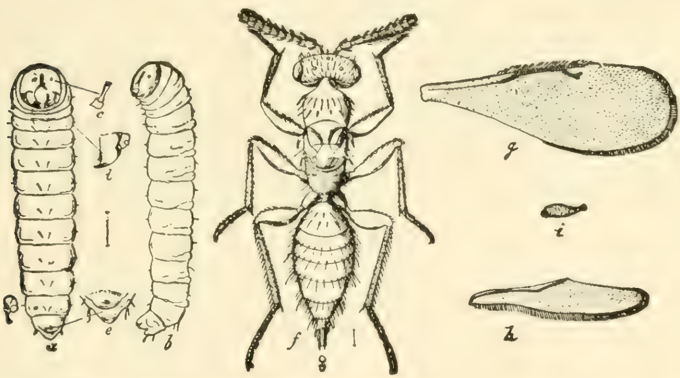


FIG. 99.—Wheat straw-worm (*Isosoma grande* Riley): *a*, ventral view; *b*, side view of larva; *c*, antennæ; *d*, mandible; *e*, anal segment, ventral view; *f*, adult female; *g*, fore-wing; *h*, hind-wing; *i*, aborted wing. (After Riley.)

short, hard bits of straw, containing the larvæ, which are carried out with the grain instead of going over in the straw. It has usually been considered necessary to separate and burn these, but Professor F. M. Webster finds that the larvæ in them are probably killed in threshing, as he has been unable to rear adults of either the joint-worm or its parasites from such bits of straw.

Control.—A rotation of the wheat crop is of primary importance in the control of this pest, and where wheat is not planted on the same land and is sown as far from that of the previous

year as possible there will be but little damage. It is obvious that the stubble should be plowed under where possible, or burned during the late fall or winter. Cut infested grain as low as possible so as to remove the larvæ in the straw. Where the stubble cannot be burned, break it down by harrowing in the spring and then collect with a hayrake and burn. Prepare the seed bed thoroughly and fertilize well, when injury is expected, so as to

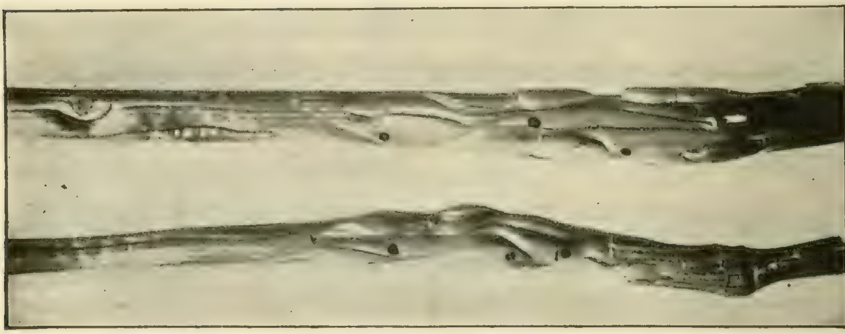


FIG. 100.—Swellings made by wheat joint-worms in straw—enlarged. (After Pettit.)

ensure a strong growth and early ripening. Green manure containing infested straw should not be scattered on land to be used for wheat, and all infested straw which has not been used up by April should be burned.

The Wheat Straw-worm *

"The Wheat Straw-worm," says Professor F. M. Webster, "sustains the same relation to winter-wheat culture west of the Mississippi River that the joint-worm does to the cultivation of this cereal east of this river. Both, when excessively abundant, occasion losses from slight to total. A wheat stem attacked by the joint-worm may produce grain of a more or less inferior quality and less of it; but the spring attack of the wheat straw-

* *Isosoma grande* Riley. Family *Chalcididæ*.

worm is fatal to the plant affected, as no grain at all is produced, and while the second generation of the same has a less disastrous effect in the field, it nevertheless reduces the grade and weight of the grain." Though the straw-worm occurs over much of the same territory in the East as the joint-worm, it is rarely so injurious.

*Life History and Description.** "There are two generations of the insect annually, the adults of the first generation differing considerably in appearance from those of the second. To the farmer they will all look like minute or large, shining black ants,

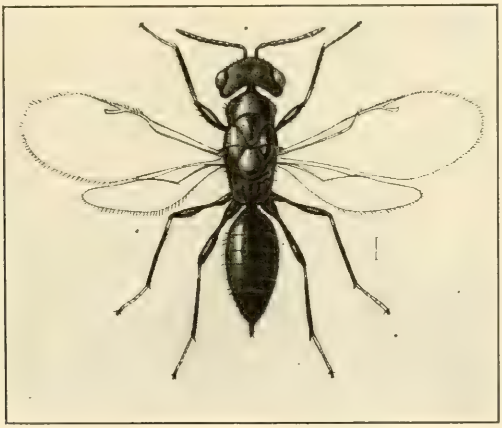


Fig. 101.—Wheat straw-worm: adult of fall generation, much enlarged. (After Howard, U. S. Dept. Agr.)

with or without wings, their legs more or less banded with yellow, and having red eyes. Individuals of the first generation emerge in April from the outstanding straws and stubble. They are very small, most of them are females, and many are wingless. The females deposit their eggs in the young wheat plants, the stems of which at this time extend but little above the surface of the ground. The egg is placed in or just below the embryonic wheat head and the larva or worm works within

* From Circular 106, Bureau of Entomology, U. S. Dept. Agr., by F. M. Webster and Geo. I. Reeves.

the stem, usually causing a slight enlargement. When the worm is full grown it will be found in the crown of the plant, having eaten out and totally destroyed the embryonic head, its body occupying the cavity thus formed.

"The females which deposit these eggs, being small and frequently wingless, are in no way fitted for traveling long distances. The larva or worm is of a very light straw color, indeed almost white, with brown jaws. These worms develop very rapidly and, as they feed on the most nutritious part of the plant, they become robust and larger than those found in the mature straw in late summer. In May the larvæ become full grown and pass at once through a short pupal stage. The pupæ are at first the same color as the larvæ, but later change to a shining jet black. In a few days the fully developed insects gnaw circular holes through the walls of the stem and make their way out. These adults are much larger and more robust than the individuals of the first generation and are provided with fully developed, serviceable wings. That they make good use of their wings, and scatter themselves about over fields adjacent to their place of development, is shown by their occurrence in fields of grasses (in the stems of which they do not breed) situated considerable distances from wheat fields. In ovipositing, the females of this generation select the largest and most vigorous-growing stems in which to place their eggs.

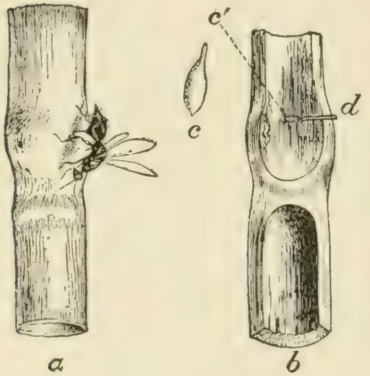


Fig. 102.—The wheat straw-worm: method of oviposition of female of summer form: *a*, female inserting her eggs, *b*, section of wheat stem, showing egg; *c*, and ovipositor, *d*; *c*, egg, greatly magnified. (After Riley and Webster, U. S. Dept. Agr.)

"The adults of the second generation deposit their eggs

from early May, in Texas, up to the middle of June, in northern Indiana, or about the time the wheat is heading. Their aim at this time is to place the eggs singly in the growing stem, just above the youngest and most succulent joints, which are not so covered by the enfolding leaf sheaths as to be inaccessible to them. Thus it is that the stage of advancement in the growth of the wheat stem at the time of oviposition of the summer generation of females determines whether the larvæ will be well upward in the straw, and therefore removed after harvest, or lower down and consequently left in the field in the stubble.

Fig. 103.—Wheat straw-worm, showing point where female of the spring form deposits the egg in young wheat in early spring. Enlarged showing position of egg at right. (After Wester, U. S. Dept. Agr.)

"The method of oviposition and the point where the egg is usually formed is shown in Fig. 103. The larva forms no gall, nor does it harden the stem within which it develops. There is normally but one larva in each joint; but if several eggs have been placed between joints and produce larvæ there will be one in the centre of the stem just above the joint and others in the walls just under the internal wall-covering or inner epidermis. These larvæ in the walls of the straws do not, as a rule, kill the stem, but their effect is to curtail the yield by reducing the weight. The larvæ develop rapidly and reach their full growth before the

straw has hardened. By October, in the Middle West, though earlier in the South, they pass into the pupal stage, in which, as a rule, they remain until early spring, whereupon they develop to adults and gnaw their way out." In the Northwest, where both winter and spring wheat are grown, the injury is particularly severe to spring wheat, as the adults of the second generation from winter wheat oviposit upon it while it is still young and ruin it in much the same way as the first generation does on the winter wheat in spring. Volunteer plants which carry the pest over winter have the same effect in increasing the injury to spring wheat.

Control.—A rotation of crops which will eliminate the growing of wheat two years in succession on the same land is by all means the most successful and practicable means of control. The adults of the first generation are very small and largely wingless; they are unable to migrate far, so that rotation is exceedingly efficacious, though it should be planned so that wheat is not planted next to stubble land, for the edge will become infested by the first generation, and the second generation will then become distributed throughout the field. The burning of stubble and outstanding straw will be advantageous wherever practicable. Clean fallowing in early summer and the abandonment of spring-wheat culture will reduce injury in the Northwest.

Wheat Saw-flies *

Several species of saw-fly larvæ sometimes feed on the leaves and rarely on the heads of wheat, but seldom do serious injury. *Dolerus arvensis* Say and *Dolerus collaris* Say have both been reared upon wheat from Ohio and New Jersey, though both species occur throughout the United States and southern Canada east of the Rockies. The adult flies "are comparatively large, robust insects, of a dull black or bluish color, varied with yellow or reddish." "The larvæ are quite uniform in color and general characteristics. They have twenty-two legs, are cylindrical, and generally of a

uniform grayish or slaty color, dorsally and laterally, but nearly white ventrally." *

The adults deposit their eggs in the spring, and larvæ are to be found early in June.

The only record found of the life history is that of *D. collaris* by Professor F. M. Webster, who found that a larva collected on June 15, 1897, entered the ground in about ten days, and the first adult emerged January 11, 1898, though the adults usually appear later.

The most common saw-fly feeding upon wheat foliage is

FIG. 104.—A wheat saw-fly (*Dolerus arvensis* Say): female—much enlarged. (After Riley and Marlatt, U. S. Dept. Agr.)

Pachynematus extensicornis Norton. "The adult insects appear during the latter part of April and first of May, the males antedating the females several days. The eggs, when first laid, are of a light green color. They are inserted to the number of two to five, or more, together along the edges of the wheat-blades and just beneath the epidermis. Some fifteen or sixteen days elapse before hatching. The newly hatched larva is rather slender and elongate, tapering gradually from the head to the last segment; head yellowish, eyes black. Full growth is attained in about five weeks,

* Family *Tenthredinidæ*. Wheat and Grass Saw-flies. C. V. Riley and C. L. Marlatt, "Insect Life," Vol. IV, p. 169.

the mature larva having a length of about four-fifths of an inch. The head is of a pale clay-yellow color, the eyes are black, and the color of the body is green or yellowish green. The larva is at once separated from the *Dolerus* larvæ by the possession of but seven pairs of abdominal feet." (R. and M., l.c.) When full-grown the larvæ enter the earth and construct silken cocoons, in which they

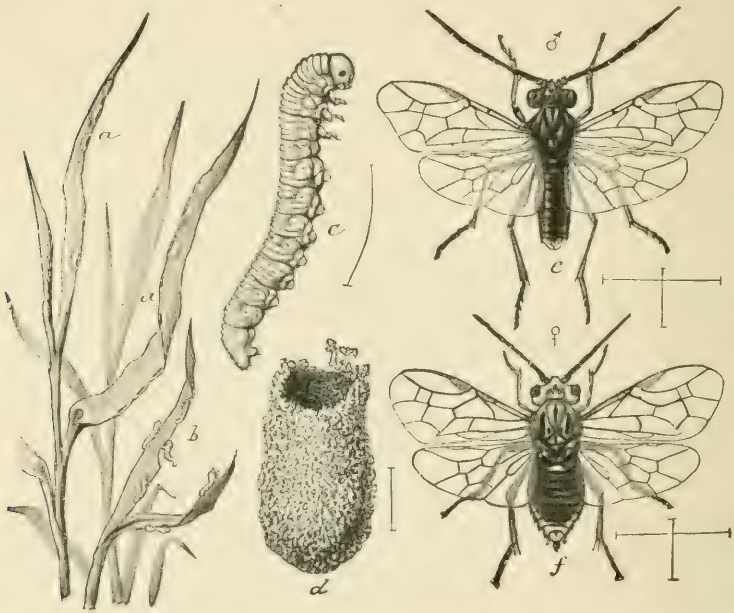


Fig. 105.—The grass saw-fly (*Pachynematus extensicornis* Norton): *a*, *a*, eggs on wheat-blade;   young larvæ; *c*, full-grown larva; *d*, cocoon from which adult has emerged; *e*, *f*, adult insects—*e*, male; *f*, female. *a* and *b*, naturalsize; *c–f*, enlarged. (After Riley and Marlatt, U. S. D. Agr.)

doubtless remain unchanged over winter, transforming to pupæ shortly before the adults emerge the next spring. The form of the adults is well shown in the illustration. "The female is stout and in general light yellowish or ochraceous in color. The abdomen is for the most part dark brown or black, dorsally, except the posterior lateral margin and the extreme tip. The male is much more slender and elongate than the female, and is almost black in color,

the tip of the abdomen being reddish and part of the legs whitish." This species has been taken on wheat in Illinois, Nebraska, Delaware, Maryland, Ohio, Indiana, and Pennsylvania. During 1886 and 1887 it did considerable damage by cutting off the heads,—sometimes, as stated by a Maryland man, cutting fully one-half of them. No more recent damage has been recorded, and owing to the slight injury usually done no remedies have received a practical test. Deep fall plowing might be of advantage by burying the larvæ so deeply that the adults would be unable to escape.

The Wheat-midge *

History.—While the Hessian fly attacks the stalk of the wheat-plant, another species of the same genus, known as the Wheat-midge, or "Red Weevil," often does very serious damage to the maturing head. It, too, is a foreigner, having first been noticed as injurious in Suffolk, England, in 1795, though probable references to its depredations date back as early as 1741. "In 'Ellis's Modern Husbandman' for 1745 the attacks of the vast numbers of black flies (the ichneumon parasites) are noticed in the following quaint terms: 'After this we have a melancholy sight, for, as soon as the wheat had done blooming, vast numbers of black flies attacked the wheat-ears and blowed a little yellow maggot which ate up some of the kernels in other parts of them, and which caused multitudes of ears to miss of their fulness, acting in some measure like a sort of locust, till rain fell and washed them off; and though this evil has happened in other summers to the wheat in some degree, yet if the good providence of God had not hindered it they might have ruined all the crops of wheat in the nation.' (Hind's 'Essay on Insects and Diseases Injurious to Wheat Crops,' page 76)". It seems probable that it was first introduced into America near Quebec, where it "appears to have occurred" in 1819, and was first observed in the United States

* *Diplosis tritici.* Family *Cecidomyidæ.* See Bulletin No. 5, Vol. I, 2d Ser., Ohio Ag. Exp. Sta., F. M. Webster.

in northwestern Vermont in 1820. It did not become very destructive, however, until 1828, from which time until 1835 is kept increasing in such numbers as to cause the abandonment of the wheat crops in some localities throughout northern New England. Serious damage was reported as due to this pest every few years until about 1860, being most severe in 1854, in which year Dr. Fitch estimated the loss in New York alone at $15,000,000, and in 1857, and 1858. Since then no widespread injury has occurred, though local outbreaks are frequent, and

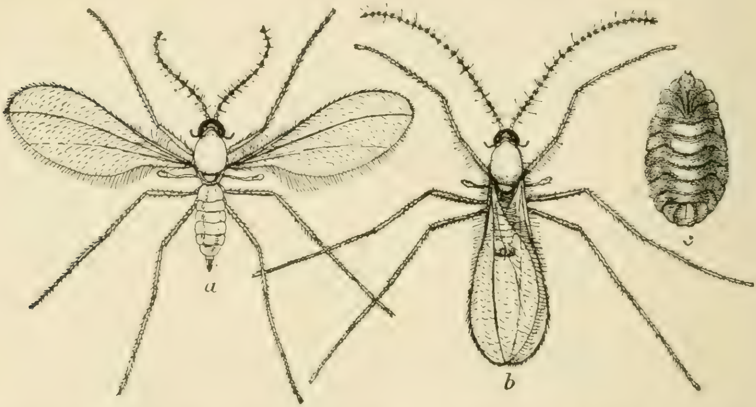


FIG. 106.—Wheat-midge (*Diplosis tritici*): *a*, female fly; *b*, male fly; *c*, larva from below. (After Marlatt, U. S. Dept. Agr.)

it has spread south to the Gulf States and westward to Iowa, Minnesota, and Arkansas.

Life History.—The adult flies are small, two-winged insects, about an eighth of an inch long, of a yellow or orange color. They appear about the middle of June and lay the eggs "in a small cavity at the summit of, and formed by a groove in, the outmost chaff covering the incipient kernel." They hatch in about a week, according to Dr. Fitch, and the maggots burrow into the forming kernels. The maggots are of a reddish color, and when an ear is badly infested give it a reddish tinge, on account of which the insect is often called the "red weevil."

When full grown the larvæ enter the ground and usually form cocoons, in which they pass the winter in the pupal stage, though they often hibernate without such protection. Though doubtless there is usually but one brood in a season, observations by Professor F. M. Webster and others seem to point to the fact that there sometimes are two broods, as adults have been observed from August into November.

Besides wheat, the wheat-midge also sometimes injures rye, barley, and oats.

Remedies.—Plowing infested fields in the fall so deeply that the midges will be unable to reach the surface upon developing in the spring is by far the best means of controlling this pest, while burning the stubble previous to plowing, and a rotation of the crop, will also be of considerable aid.

The English Grain-louse *

The most common plant-louse affecting wheat and other small grains is a large green species which is always to be found on wheat plants, but which occasionally increases very rapidly, and clustering on the ripening heads sucks the juices so as to seriously injure the quality and weight of the wheat.

In the North the first individuals are found on young wheat in April, though during open winters they may be found on the plants, and in the South they continue to reproduce during most of the winter in open seasons. The aphides feed upon the leaves until the grain commences to head, when they assemble on the heads among the ripening kernels. The females give birth to live young, bearing from 40 to 50 each, which become full grown in ten days to two weeks, and then reproduce, as is the usual method of reproduction with plant-lice (see page 442), so that they

* *Macrosiphum granaria* Buckton. Family *Aphididæ.* A nearly related species, *Macrosiphum cerealis* Kaltenbach, has very similar habits, is commonly associated with the species, and has not been distinguished from it by most writers. It may be recognized by lacking the blackish markings on the abdominal segments. See Pergande, Bulletin 44, Bureau of Entomology, U. S. Dept. Agr.

multiply with great rapidity, and where so few were present as to be hardly noticeable, in a few weeks they will be swarming over the heads in myriads. As the small grains ripen they migrate to various grasses and are not much in evidence during midsummer, but later migrate to volunteer oats and wheat, upon which they subsist until fall wheat is available. Owing to the cool weather of fall and the fact that but few individuals survive the attacks of their parasites during the summer, they rarely become abundant enough to do any damage to grains in the fall. So far as known, they hibernate over winter among the leaves of the growing plants, enough surviving both snow and cold to infest the crop the next spring. Whether true males and females produce eggs on the grain is unknown, for though they have been reared under artificial conditions, they have never been observed in the field. Professor F. L. Washburn observed at least fourteen generations up to November 8, 1907, in southern Minnesota.

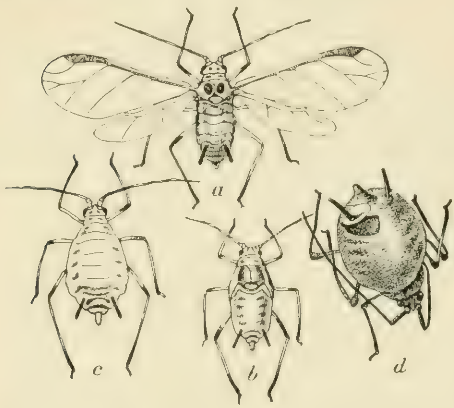


Fig. 107.—The German grain aphis (*Macrosiphum cerealis* Kalt): *a*, winged migrant; *b*, nymph of same; *c*, wingless parthenogenetic female; *d*, same showing exit hole of parasite—enlarged. (After Riley, U. S. Dept. Agr.)

As with other aphides, both winged and wingless individuals occur throughout the season. The wingless individuals are about one-tenth inch long, with black antennæ as long or longer than the body, are of a yellowish-green color, often slightly pruinose, and long black nectaries extend from either side of the abdomen. The winged individuals are about the same length, with a wing expanse of about three-eighths inch, with antennæ a third longer than the body, and are of the same general coloration except that lobes of the thorax are brown or blackish, and

the abdomen is marked with four or five transverse blackish spots in front of the nectaries.

Like the other aphides affecting small grains, this species is held in check by parasitic insects, aided by predaceous insects and fungous diseases. Injury by the aphides is usually due to the parasites having been killed off, thus giving the aphides opportunity to multiply unchecked. Among the most abundant parasites are species of the genus *Aphidius* (family *Braconidæ*), one of which is shown in Fig. 109, greatly enlarged. Cold, wet weather in spring greatly retards the development of these parasites, so that the aphides are always more numerous in such seasons. It has also been observed that an outbreak is often preceded by several dry seasons, which may be due to the fact that such dry seasons check the development of fungous diseases which kill off large numbers of the aphides and which do not propagate in hot dry weather. Thus weather conditions are very intimately

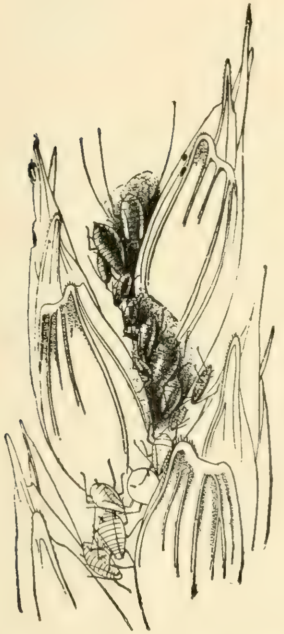


Fig. 108.—Grain aphides clustered on wheat head, greatly enlarged. (After Weed.)

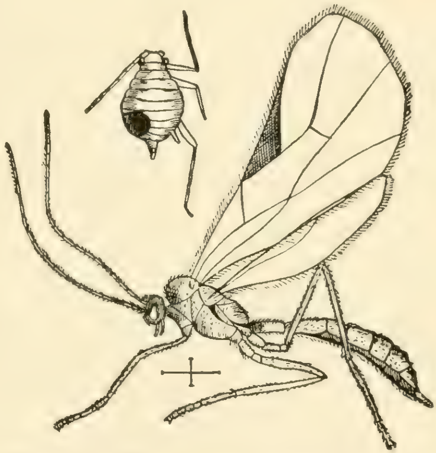


Fig. 109.—Wheat-louse parasite (*Aphidius avenaphis* Fitch), and parasitized louse from which it has issued. (Copied from J. B. Smith.)

associated with the abundance of the pest. When the parasites become abundant they will often completely rid a field of the aphides within a few days. All of the common ladybird-beetles (*Coccinellidæ*), Syrphus-fly larvæ, and lace-winged fly larvæ (*Chrysopidæ*) are commonly found feeding upon the aphides.

Control.—No practical remedy for this species is known nor are means of control easily suggested. The suppression of volunteer wheat and oats in early fall will prevent the multiplication of the pest before fall-sown wheat is available, and the late sowing of wheat in the fall will reduce the numbers entering hibernation. A wise rotation and the thorough preparation of the seed-bed and liberal fertilization will be of value in avoiding injury in the same way as has been described for other pests of small grains. Fortunately this species rarely does very widespread injury and its parasites usually soon bring it under control.

The Spring Grain-aphis or Green Bug *

Though long known as a serious pest of small grains in Europe, this aphis has done widespread injury in this country only during the past ten years. Though it occurs throughout the territory north of latitude 41°, with the exception of the North Atlantic States, as far west as longitude 105°, the worst injury has been done in northern Texas, Oklahoma, and Kansas, though it has also been injurious in the Carolinas and Tennessee.

The habits of the insect during the winter have not been sufficiently studied to speak authoritatively, but it seems probable that it normally passes the winter in the egg stage, the small shining black eggs, one-fortieth inch long, being laid on the leaves in the late fall. In the South, however, it often continues to reproduce throughout the winter, and with a mild winter the numbers so multiply that unless checked by parasites serious injury is done by late winter or early spring. Both wingless and winged forms occur throughout the year. The wingless female is from one-twenty-fifth to one-fourteenth inch long, yellowish-green, with a median line slightly darker, eyes and most of the

* *Toxoptera graminum* Rond. Family *Aphididæ*.

antennæ black, of the shape shown in Fig. 112. The winged female is slightly larger, with a wing expanse of about one-quarter inch, and of the same general coloration, except that the head is brownish-yellow and the lobes of the thorax are blackish. The aphides hatching from the eggs are all females, which give birth to live young, no male forms occurring during the summer. During her life of slightly over a month a female will give birth to 50 or 60 young, which commence to reproduce in the same manner

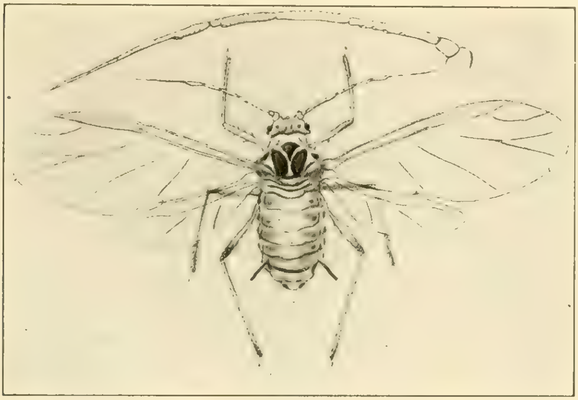


Fig. 110.—The spring grain-aphis or "green bug" (*Toxoptrea gramimum*): *a*, winged migrant; *b*, antenna of same. *a*, much enlarged; *b*, highly magnified. (From Pergande, U. S. Dept. Agr.)

when about seven days old, so the numbers of the pest obviously increase with enormous rapidity, and with thousands of tiny beaks pumping out the sap the young grain plants soon succumb. The rate of reproduction and growth is, of course, much slower in colder weather, the above being the average for the growing season. Thus in an open winter the aphides will continue to multiply, and by February, in northern Texas, small spots of wheat and oats will show the effect of their work, by March the injury may become widespread and serious, and by the middle of April the crops may be ruined. As the aphides become excessively abundant and the

food supply disappears, almost all develop wings, and immense clouds of the winged females are carried northward by the winds, so that an outbreak in early spring in the South leads to an infestation farther north, and excessive multiplication will again carry the pest still northward, progressing in that direction as it increases during the season, rather than being spread at one time. Thus in 1907 it became abundant in Oklahoma in April, in Kansas

FIG. 111.—Green bugs on oat-seedling—enlarged.

in May, and by July it was found in Minnesota, where it rarely occurs and does no damage. With the maturing of wheat and oats the aphides migrate to various grasses, being particularly fond of Kentucky blue-grass, and may subsist on corn, on which they may feed until oats and wheat are available in the fall. Oats are the favorite food, and outbreaks of the pest have always been worst where volunteer oats are generally grown, the aphides increasing on them in the early fall and winter and later spreading to wheat. By October 15th in Minnesota and by early November in Kansas the true winged males and wingless egg-laying females have been

observed, but strangely enough they have only been secured in small numbers by being reared in the laboratory, and have not been observed in the field, so that although these females laid eggs freely on the leaves of grain, we do not know whether they are essential or not to the life history of the insect in the field, for while the eggs are being produced other females continue to give birth to live young until the cold of winter, and they have been

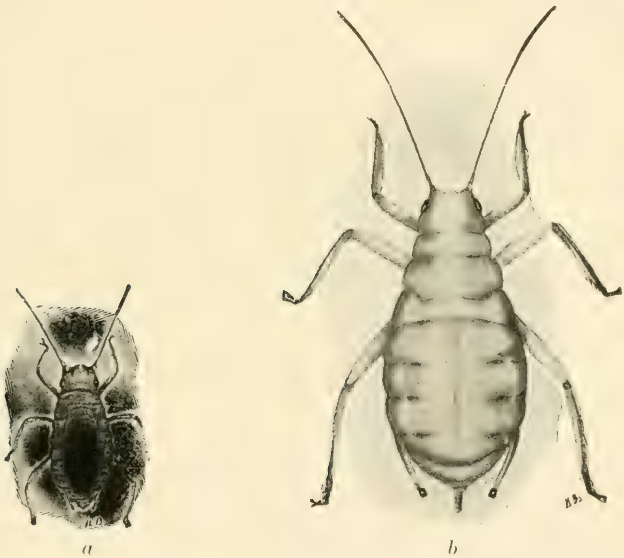


FIG. 112.—*Toxoptera graminum*: *a*, newly born, and *b*, adult wingless green bug, greatly enlarged. (After S. J. Hunter.)

observed to reproduce with a daily mean temperature barely above freezing.

Natural Control.—The natural control of this most destructive pest involves a most interesting relationship between temperature and the development of the parasites which check its development. "The 'green bug' in normal years—that is, when its breeding begins in spring—is effectively held in check by its natural enemies, and notably by a minute, black wasp-like insect, *Lysiphlebus testaceipes* Cress. (Fig. 113), that deposits eggs singly in the 'green

bugs,' the grubs hatching from the eggs feeding internally on the bug and destroying it (Figs. 115, 116). Other natural enemies are the larvæ of certain predaceous flies, and the larvæ and adults of lady-beetles. The little wasp-like parasite first mentioned, however, is the one that keeps the 'green bug' in control in normal years, and in years when the latter is most abundant finally overcomes it, as was the case in 1907 in Kansas, North Carolina, and other States in the more northern part of the range of the pest."

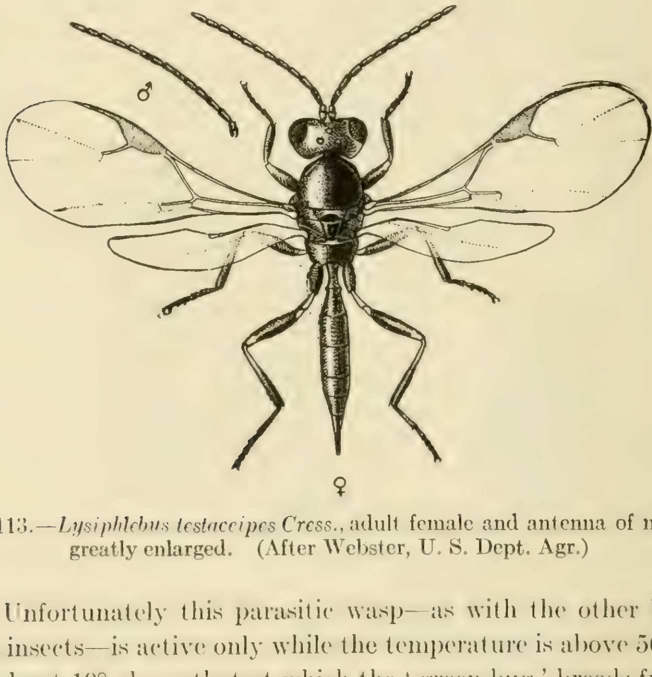


Fig. 113.—*Lysiphlebus testaceipes Cress.*, adult female and antenna of male—greatly enlarged. (After Webster, U. S. Dept. Agr.)

"Unfortunately this parasitic wasp—as with the other beneficial insects—is active only while the temperature is above 56° F., or at least 10° above that at which the 'green bug' breeds freely; and herein is the whole secret of the irregular disastrous outbreaks of the 'green bug' in grain fields. As accounting for the outbreak in the year 1907, the 'green bug' had had a whole winter and the following late spring in which to breed and multiply unmolested, and it accomplished its principal damage, as in Texas and southern Oklahoma, before the weather was warm enough for the parasite to increase sufficiently to overcome it."

"As further illustrative of the important bearing of weather conditions, it is found that in the case of the three important outbreaks of this insect, namely, for the years 1890, 1901, and 1907, the temperature for the first five months of each of these years, including the latter part of the winter and spring, was above the normal for the winter months and below the normal for the spring months; in other words, warm winters and cold, late springs."

"The little parasitic wasp which is so useful in the control of this pest is native to this country, widely distributed, and every year does its work with the 'green bug' and with other aphides. It is always present in grain fields, as shown by its appearance every year, to war on these pests whenever the weather conditions make its breeding and multiplication possible, and its rate of breeding is so rapid (there being a generation about every ten days) that with a week or two of favorable weather it gains control over its host insects and destroys them." * Extensive experiments were conducted in Kansas in 1907 in importing these parasites from

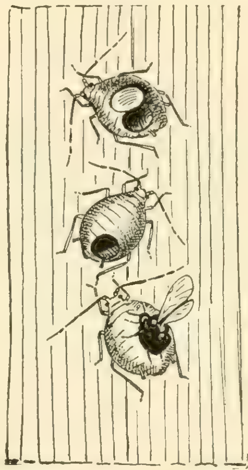


FIG. 115.—Dead "green bugs," showing hole from which the matured parasite of *Lysiphlebus* emerges. The top figure shows the lid still attached, but pushed back; the bottom figure shows the parasite emerging. Enlarged. (After Webster, U. S. Dept. Agr.)

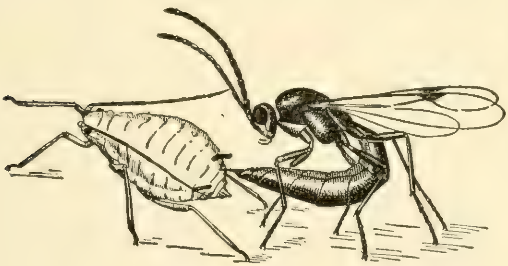


FIG. 114.—*Lysiphlebus* parasite in act of depositing eggs in the body of a grain-aphis—much enlarged. (After Webster, U. S. Dept. Agr.)

* From F. M. Webster, Circular 93, Bureau of Entomology, U. S. Dept. Agr. See also Bulletin of the University of Kansas, Vol. IX, No. 2, by S. J. Hunter, The Green Bug and Its Natural Enemies.

farther south before they had become abundant in Kansas fields so as to hasten their control of the aphides, but further experiments will be necessary before it can be determined whether such a method of colonizing the parasites is practically effective or not.

Control. Most important of all methods of control is the abandonment of the growing of volunteer oats and the destruction of all volunteer oats and wheat in the early fall. Universal experi-

Fig. 116.—Parasitized green bugs enlarged. (From photograph, after S. J. Hunter.)

ence throughout the injured area shows that relatively little injury occurs where volunteer oats are not grown.

Where small spots of grain have been injured by the pest in late winter, which is the way an outbreak usually begins in southern localities, the aphides on these small spots may be killed by spraying with 10 per cent kerosene emulsion, or whale-oil soap, 5 pounds to a barrel of water, by covering the spots with straw and burning, or by plowing under the infested spots. Were this generally done before the aphides commence to multiply rapidly, it is entirely possible that widespread injury might be averted.

CHAPTER IX.

INSECTS INJURIOUS TO CORN

The Western Corn Root-worm *

THROUGHOUT the corn States of the northern Mississippi Valley, wherever corn is grown upon the same land it is subject to serious injury by the Western Corn Root-worm, so called because it first became injurious in Missouri and Kansas and gradually spread eastward to Ohio, though not injurious south of the Ohio River.

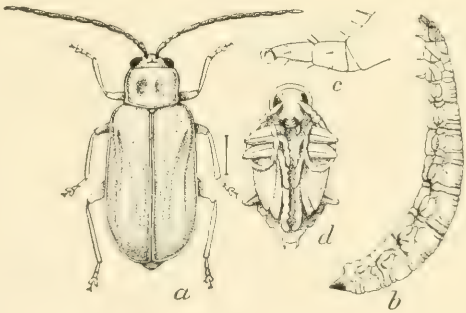


FIG. 117.—The western corn root-worm: *a*, beetle; *b*, larva; *c*, enlarged leg of same; *d*, pupa—all enlarged. (After Chittenden, U. S. D. Agr.)

Though the life history of the insect has not been entirely determined, the following summarizes it as observed by Professors S. A. Forbes and F. M. Webster in Illinois and Indiana. The eggs are laid in the early fall, within a few inches of the base of the stalk, and just beneath the surface of the soil. The egg is a dirty white color, oval in shape, and about one-fiftieth inch long. The winter is passed in the egg stage, differing from most nearly related beetles in this, and the eggs hatch in the spring or early summer. At first the larvæ eat the small roots entire, but later burrow under the outer layers of the larger roots, causing the stalks on rich loam to

* *Diabrotica longicornis* Say. Family *Chrysomelidæ*.

be easily blown over, or dwarfing the plant on poorer land so that it produces but small ears. The full-grown larva is nearly white with a brown head, a little less than one-tenth inch long by about one-tenth inch in diameter. Three pairs of short legs are found on the thorax, but otherwise the body appears perfectly smooth to the eye, though finely wrinkled. Before pupation the color becomes slightly darker and the body shortens. Leaving the roots, the larvæ then form small oval cells in the soil and in them transform to pupæ, from which the adult beetles emerge in a short time. The beetles appear from the middle of July on through August, about two mor ths being required for development after hatching from the egg. The beetles are of a greenish or greenish-yellow color, about one-quarter inch long, and resemble the common striped cucumber-beetle (page 379) in form. They are to be found in the corn-fields feeding upon pollen and silk until the latter becomes dry, and lay their eggs during August and September. The beetles are often found feeding upon various weeds, clover, beans, cucumber and squash vines, and the blossoms of thistle, sunflower and golden rod.

Control.—As the larvæ feed only on corn, if the corn-field be planted to some other crop, starvation results, and a simple rotation in which corn is not allowed on the same land for over two years in succession usually prevents injury, though a field in which injury has occurred should be planted to some other crop at once. It is imprudent to plant corn on fields in which the beetle has been observed feeding in large numbers on clover and weeds during the late fall of the previous year. The liberal use of manure and fertilizers, and thorough cultivation will, of course, be of service in enabling the plants to withstand attack.

The Southern Corn Root-worm *

Closely related to the last species, but with somewhat different habits, the Southern Corn Root-worm is frequently injurious to corn from Maryland and southern Ohio southward.

* *Diabrotica 12-punctata* Oliv. Family *Chrysomelidæ*.

The adult beetle is of a bright green marked with twelve black spots, which have given it the name of 12-Spotted Cucumber-beetle to distinguish it from the Striped Cucumber-beetle (page 379), with which it is often associated feeding on cucurbs. It is somewhat larger and more robust, than *D. longicornis,* and is almost omnivorous in its food habits, feeding upon the foliage and flowers of a long list of forage and garden crops, to which it often does

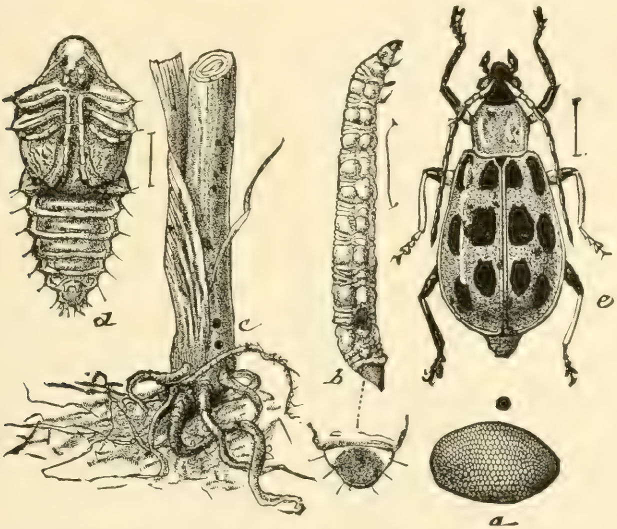


FIG. 118.—The southern corn root-worm: *a*, egg; *b*, larva; *c*, work of larva at base of cornstalk; *d*, pupa; *e*, beetle—all much enlarged except *c*. (After Riley.)

considerable damage. Beans are frequently injured in much the same way as corn and the roots of melons and other cucurbs are often so riddled by the larvæ as to kill the plants.

Injury to corn is done by the larvæ in the spring, when they feed upon the roots while the corn is but a few inches high, bore into the crown, and boring into the base of the stalk through the young leaves eat out the " bud." The latter injury often seems to be more serious to corn than the injury to the roots, and has given the insect the common local name of " budworm," which is unfortunately applied to several other insects which do similar

injury. Larvæ have been found attacking wheat, rye, millet and Johnson grass in a similar way, the beetles seeming to be attracted to fields containing Johnson grass before the corn appears, thus injuring such grassy fields more severely. Injury to corn seems to be worse on low, damp spots.

Life History.—The beetles hibernate over winter and are among the first insects to appear in early spring, appearing by the middle of March in the Southern States. Eggs are laid during April in the Gulf States and from late April to early June in Kentucky and the District of Columbia. The egg is dull yellow, oval, and about one-fortieth inch long. The eggs are laid singly just beneath the surface of the soil and hatch in from seven to ten days, those laid early in the season requiring considerably longer. The larvæ become full grown and pupate about a month later, the adult beetles of the first generation appearing during May and early June in the Gulf States and in late June and early July in the District of Columbia and Kentucky. Thus the complete life cycle requires from six to nine weeks in the spring. Eggs are laid by the first generation of beetles, the larvæ being found on the roots of corn from midsummer until fall, when the second generation of beetles is found in October and November in Kentucky. In the Gulf States there are undoubtedly three complete generations, though they have not been carefully followed.* The beetles assemble on clover and alfalfa in the late fall, upon which they feed until winter sets in, and often come out and feed during warm spells in January and February in the Southern States.

Control. Although rotation of crops will not be as effective in the control of this species as in the case of *D. longicornis*, it will undoubtedly be found of value to avoid planting corn in succession where injury is probable. By planting late after the beetles have laid their eggs, injury has been avoided in Georgia. Liberal seeding, using ten grains of seed per hill, will give a sufficient stand free from attack, so that by thinning a good stand may be secured.

* In the Northern States, where this species is not a pest of corn, but is common on cucurbs and garden plants, there is probably but a single generation with a life history very similar to that of the striped cucumber-beetle, see page 379.

Fields which are well infested with Johnson grass, or other thick-stemmed grasses, should be avoided, for as already indicated the beetles will be attracted to them before the corn is up. Both on account of the feeding habits of the larvæ and the migratory habits of the beetles no insecticide treatment commends itself as practicable.

The Corn-root Webworm *

Injury.—When young corn-plants are seen to stop growing, become deformed, and to die off in such numbers as to frequently necessitate replanting, upon examination of the roots the injury will sometimes be found to be due to the work of a small caterpillar. Two or three, very often five or six, and sometimes as many as eight or nine will be found at the base of a plant about an inch below the surface of the soil, and not over 4 to 6 inches from the stalk, usually being in close proximity to it. If each larva is covered with a fine, loose web, to which cling particles of earth forming a sort of case, it is probably a corn-root webworm.

Where the webworms are present in any number they will often necessitate a second, third, or sometimes a fourth planting, making the corn very late and involving considerable expense. The worms bore into the young stalks just above the ground, frequently cutting them off entirely. Later on the larger stalks are gouged out at or slightly above the surface of the ground, and the larvæ burrow into the folded leaves, which when they unfold have several transverse rows of three to five holes. On account of this habit these insects are sometimes known as "budworms." Strong plants will often make a new start and survive the injury, but remain much behind those not attacked, while most of the weaker plants will decay and rot off.

The Moth.—As one walks through pasture or grass land, many little white and yellowish moths are seen flying about on all sides, but quickly disappear as they alight on the grass. If a single individual be watched more closely, it will be noticed that in alighting upon a blade of grass it quickly rolls its wings

* *Crambus caliginosellus* Clem. Family *Crambidæ.*

very tightly around its body, and hugs up close to the grass so that it is hardly distinguishable from it. Projecting from the head in front is what appears to be a long beak or snout, on account of which these moths are often known as "snout-moths," but which really consists of the palpi or feelers. The "grass-moths," as they are sometimes called, belong to the genus *Crambus* and include several common species, which are marked with silver stripes and bands, as well as golden lines and markings, so that they often present a very handsome appearance.

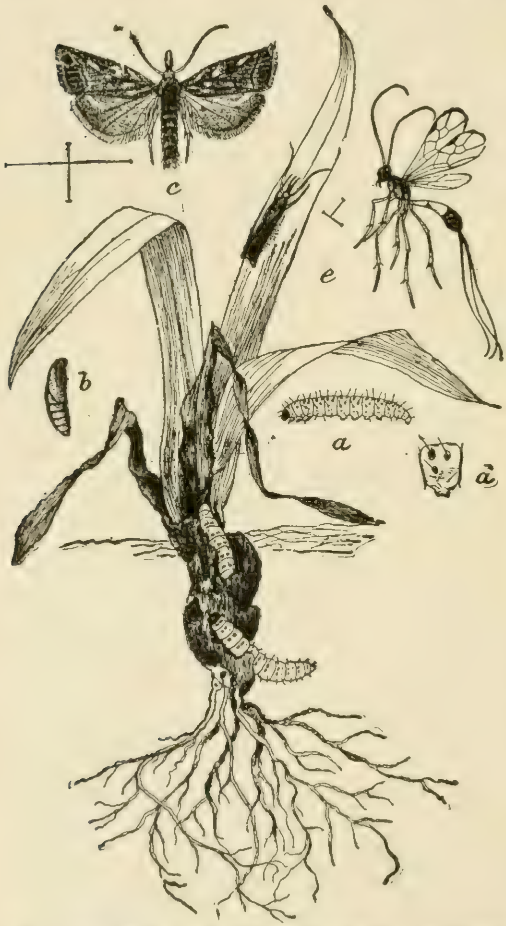


FIG. 119.—The corn-root web-worm (*Crambus caliginosellus*): *a*, larva; *b*, pupa; *c*, moth; *d*, segment of larva; *e*, parasite. (After Johnson.)

Life History.—These are the parents of the web-worms which do so much injury to the young corn-roots, the principal depredators upon corn belonging to the species *Crambus caliginosellus*. They lay their eggs in grass land in May or early June, dropping them on the surface among the rubbish or vegetation, or attaching them to the

grass. They are oval in form and of a yellowish color, each being marked with regularly placed ridges. About two hundred eggs are laid by each female. In from six to ten days the eggs hatch. The young larvæ soon form their loose silken webs or tubes at or a little below the surface of the soil, burrowing among the roots, and feeding upon the stalk and outer leaves, or killing the plant by attacking the crown. The larvæ vary considerably in color, from a yellowish white, through pink, to a reddish or brownish shade, and are studded with small tubercles, each bearing a tuft of bristly hairs. The larvæ become full grown in from five to seven weeks and are then from one-half to three-fourths of an inch long. During the latter part of July they form cocoons, sometimes in the larval tubes, in which they pass the pupal stage and from which the moths emerge some twelve to fifteen days later. Eggs are laid for another brood in grass lands during August and September, the larvæ hatching in September and October and becoming partly grown before winter. They hibernate in their webs over winter, and as soon as the grass commences its growth in the spring they are to be found feeding upon it, becoming full grown early in May.

Preventive.—As the natural food of these insects is grass, it is not surprising that corn planted on sod land should be worst injured; and though the injury done the grass may not have been noticeable, when the available food is so greatly diminished by substituting for grass the comparatively few hills of corn the injury becomes much more serious and apparent. Though the planting of corn on sod land is a most common practice, injury by this and many other insect pests of corn—most of whose native food is grass—might be avoided by planting any other crop than a grain, such as potatoes. Otherwise plowing late in the fall and harrowing so as to expose the larvæ to the weather, or plowing so deeply that they will be buried so that they cannot regain the surface, will do much to prevent injury the next season. Inasmuch as the moth will not lay her eggs upon plowed land, if the land be plowed early she will be driven to other fields; but the exact time of oviposition varies for different latitudes.

Generous fertilization will aid the plants in overcoming injury very considerably. Dr. J. B. Smith advises "the application of all the necessary potash in the form of kainit, put on as a top-dressing after the field is prepared for planting," and says: "Fall plowing and kainit as a top-dressing in spring will, I feel convinced, destroy by all odds the greater proportion of the web-worms that infest the sod, and would also destroy or lessen many other pests which trouble corn during the early part of its life."

The Corn-root Aphis *

Where patches of corn become dwarfed, the leaves becoming yellow and red, with a general lack of vigor, the grower may well be suspicious of the presence of the Corn-root aphis. These little aphides, which cluster on the roots of corn, are a bluish-green color, with a white waxy bloom, and of the form shown in Fig. 120. Two short, slender tubes project from the posterior part of the abdomen which are commonly called honey-tubes, because they were formerly supposed to give out the honey-dew, which is so relished by the ants which tend the aphides to secure it. The winged female has a black head and brownish-black thorax, with pale green abdomen bearing three of four blackish marginal spots and small dark specks over the surface. The antennæ are dark and the legs blackish.

The corn-root aphis occurs throughout the principal corn-growing States, but has been most destructive where corn is most extensively grown and is often planted year after year on the same land. Dr. Forbes, to whom we are indebted for most of our knowledge of this pest,† has observed fields of corn in Illinois planted in corn for the second season totally ruined by the root-aphis. Broom-corn and sorghum are the only other cultivated crops which have been injured, but the list of food plants includes smartweed, purslane, ragweed, foxtail, and crab-

* *Aphis maidi-radicis* Forbes. Family *Aphididæ*.

† S. A. Forbes, 17th, 18th, and 25th Reports of the State Entomologist of Illinois; Bulletin 60, Bureau of Entomology, U. S. Dept. Agr., p. 29; Bulletins 104 and 130, Illinois Agr. Exp. Sta. See also J. J. Davis, Bulletin 12, Part VIII, Technical Series, Bureau of Entomology, U. S. Dept. Agr., and F. M. Webster, Circular 86, Bureau of Entomology, U. S. Dept. Agr.

grasses, and many other weeds and grasses which spring up in the corn-field. In South Carolina Professor A. F. Conradi has found it injuring cotton.

If the nests of the small brown ant * so common in corn-fields infested with the root-aphis, be broken open during the winter, many of the little black aphis eggs, which have been carefully stored by the ants, will be found. They are a glossy black color,

FIG. 120.—The corn root-aphis (*Aphis maidiradicis* Forbes): at left, oviparous female; *a*, hind tibia, showing sensoria; at right, male; *a*, antenna —much enlarged. (After Forbes.)

oval in shape, and will sometimes be found in small piles in the chambers of the ants' nests. On warm days the ants bring them up to the warmer surface soil and in cold weather carry them far down into the unfrozen earth. With the appearance of young smartweed and foxtail-grass in April and May the eggs commence to hatch. The ants at once lay bare the roots of these plants and carry their young wards to them, where large colonies soon become established. If the field is not planted in

* *Lasius niger* Linn. var. *americanus* Emery. See Forbes, Bulletin 131, Illinois Agr. Exp. Sta.

corn, the lice will feed later upon the roots of pigeon-grass or purslane. In early May the second generation of lice commence

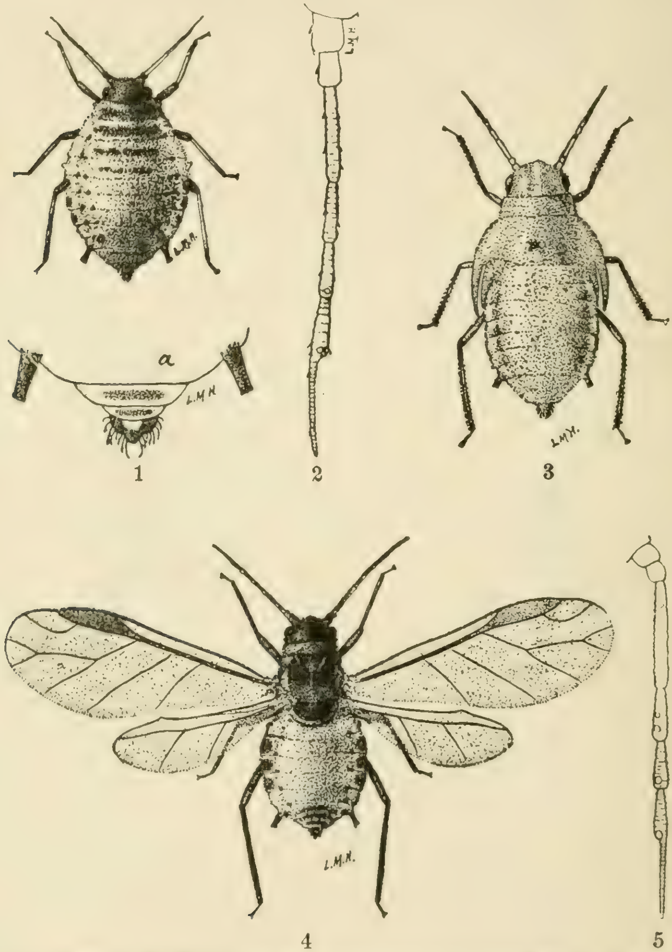


FIG. 121.—The corn-root aphis (*Aphis maidi-radicis* Forbes): 1, wingless vivaparous female; *a*, apex of abdomen; 2, antenna of same; 3, pupa; 4, winged vivaparous female; 5, antenna of same. (After Forbes.)

to appear, among them being both wingless and winged forms. This brood and all of these during the summer are produced by females known as agamic females, which give birth to live young

without mating with a male. As soon as corn plants are available the ants again transfer the aphides to their roots, and carry any winged aphides which may have spread over the field down on to the roots of the corn. All through the summer the ants attend the lice, burrowing around the roots of the corn, and carrying them from plant to plant, in return for which the aphides give off the sweet honey-dew, when stroked by the ants' antennæ, upon which the ants feed. During the summer the aphides continue to reproduce with extreme rapidity, an aphid maturing and giving birth to young about eight days after it is born,

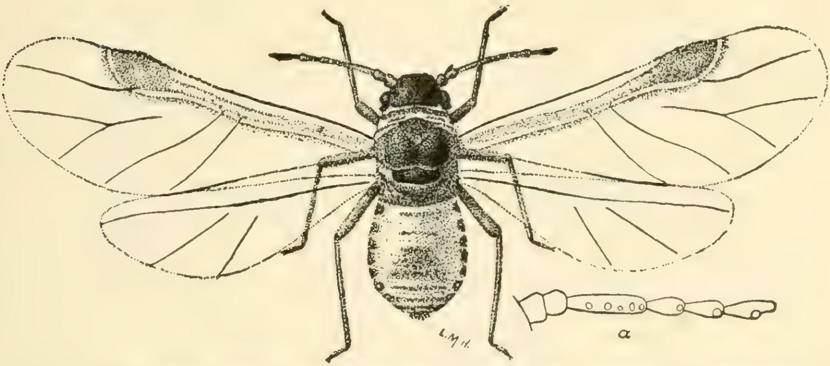


Fig. 122.—Grass root-louse (*Schizoneura panicola*); winged vivaparous female. *a*, antenna. (After Forbes.)

each generation taking about sixteen days and there being about twelve generations during the season. Both winged and wingless agamic females occur throughout the summer, but late in September and in October wingless forms which develop into true males and females are produced. These mate and the females lay eggs during October, most of them being carried by the ants to their nests, where the eggs are laid.

Control.—Owing to the fact that the aphides do not migrate until the second generation, a rotation of crops will be of great service in checking their injuries, as corn planted on uninfested land will not be attacked until it has been able to secure a good start, and if well fertilized will be able to successfully withstand

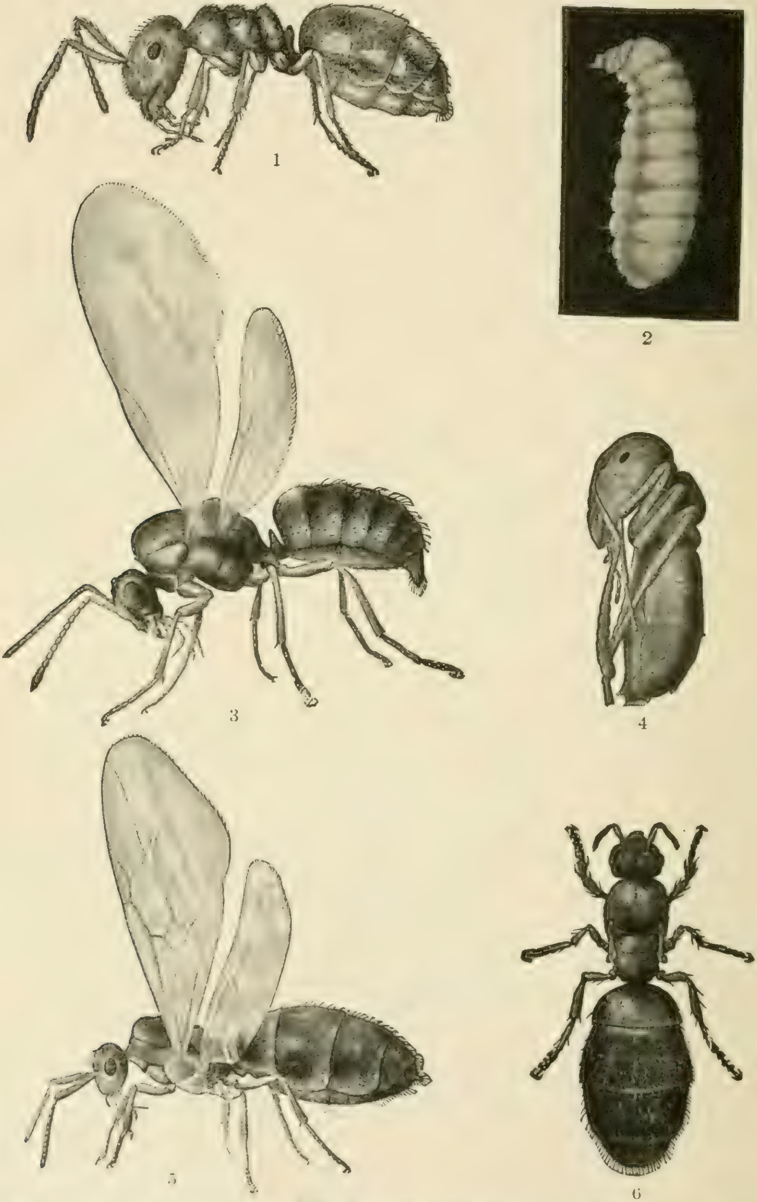


FIG. 123. The corn-field ant (*Lasius niger americanus*): 1, worker; 2, larva; 3, winged male; 4, pupa; 5, winged female; 6, female with wings removed. (After Forbes.)

whatever injury may occur. Rarely is corn on land not in corn the previous year seriously injured, and where infestation has not been serious throughout a community, it may usually be grown two years in succession with safety.

The proper fertilization of plants affected with root insects is always of great importance, enabling the plant to make a crop in spite of them if the attack is not too severe. Professor F. M. Webster observes that land which has been fertilized with barnyard manure is much less injured by this insect than that where commercial fertilizers are used.

As the ants not only spread the pest during spring and summer, but house the eggs in their nests over winter, any means for destroying their nests will be of importance in controlling the aphides. Where it is practicable, deep plowing in late fall and winter, with thorough harrowing, will break up the nests, and land so treated has shown decidedly less injury the next season. Similarly plowing deeply and harrowing several times in spring not only breaks up the ants' nests, but destroys the weeds and grasses upon which the aphides feed before corn is up, and also furnishes the best possible seed-bed and soil conditions. This should be particularly thorough in low spots where weeds are thickest and where the aphides appear first. Such spring cultivation has been demonstrated as very effective in the control of the pest. In recent years Professor S. A. Forbes has conducted experiments in Illinois which seem to show that dipping the seed in a repellant such as a lemon oil will render it obnoxious to the ants, and thus protect the hill. This has not proven successful, however, when heavy rains followed planting and washed off the repellant. Lemon oil was used by adding 1 gallon of wood alcohol to 1 pint of oil of lemon, of which 3 fluid ounces (6 tablespoonfuls) were stirred into each gallon of seed used, being sure that all the seeds were well coated. Such a treatment cost about ten cents per acre and resulted in reducing the number of aphides 89 per cent and the number of ants 79 per cent, so that it may well be given a trial, but the chief reliance should be placed upon rotation and early cultivation.

The Corn Leaf-aphis *

Although the corn leaf-aphis is not often very seriously injurious to corn, in Texas and other Southern States it frequently becomes so abundant on sorghum and corn, and in winter on barley, as to do considerable injury. This species is also of interest in that it appears on corn foliage in midsummer at the time when the numbers of the root-aphis commence to decrease on the roots,

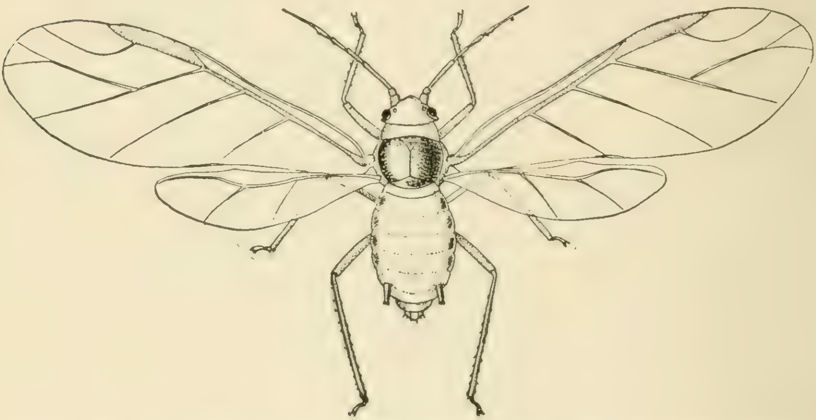


FIG. 124.—The corn leaf-aphis (*Aphis maidis* Fitch): winged female—much enlarged. (After Webster, U. S. Dept. Agr.)

and it was for many years thought to be the same species. Careful rearing experiments made under the direction of Dr. S. A. Forbes have failed to show any connection between the root-aphis and leaf-aphis, the aphides from the roots being unable to establish themselves on the leaves and those on the leaves never migrating to the roots.†

Dr. Forbes describes the species in his twenty-third report as follows: "In the latter part of the summer this bluish-green plant-louse may occasionally be found on the younger leaves,

* *Aphis maidis* Fitch. Family *Aphididæ*. See Webster and Davis, l.c., p. 164.

† S. A. Forbes, 13th, 16th, 18th, and 23d Reports of the State Entomologist of Illinois.

the tassel, and the upper part of stalks of corn, and more abundantly and frequently on broom-corn and sorghum. Multiplying in place by the birth of living young, which do not wander from their place of origin, these leaf-lice may become abundant enough to kill the leaves and to some extent to effect the health of the plant. The insect is, however, rarely seriously injurious to corn, but there is some evidence, . . . that it may prevent the fertilization of the kernel by sucking the sap from the silk and killing it before it has performed its function. Heavily infested corn leaves turn yellow or red, and may shrivel and die, particularly if the weather be dry at the time. Broom-corn is considerably damaged by a reddened discoloration of the brush, due to a bacterial affection following upon the plant-louse punctures.

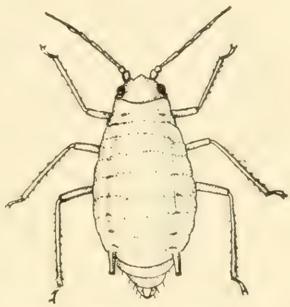


Fig. 125.—The wingless female of the corn leaf-aphis — much enlarged. (After Webster, U.S. Dept. Agr.)

"The wingless form of this aphis is about 2 mm. (one-twelfth inch) long and half as wide at the widest part, the body being somewhat ovate in outline. The general color is pale green, with the cauda, cornicles and the greater part of the rostrum, antennæ and legs black. The head is marked with two longitudinal dark bands, and the abdomen with a row of black spots on each side and a black patch about the base of the cornicles. The latter are swollen in the middle, making the outlines convex. . . . The winged form is somewhat different in color, the head being black and the thorax chiefly black above. The abdomen is pale green, bluish at the sides, with two transverse black bands preceding the cauda, and the segments behind it edged with dark." These differences between this and the root aphis are shown in the accompanying figures. "*Aphis maidis* has been reported at various times as a corn insect from New York to Texas, Minnesota and California. The species makes its appearance

in midsummer, our earliest date (Illinois) being July 9, when specimens were found on young leaves of corn. We have no record whatever to show whence it comes or where it lives preceding this time. Having once commenced to breed on the food plants mentioned, it continues there until freezing weather overtakes it, when, with the death of its food plants, it gradually disappears, leaving neither eggs nor hibernating adults on or about these plants, and passing the winter we do not know how or where." Its occurrence on barley in Texas in January may throw some light upon its wintering habits in the South. "The latest to develop in the field largely acquire wings, and as the sap supply in the plant diminishes they fly away. Wingless females, on the other hand, perish on the spot. Indications are thus very strong that this is a migrating species whose second food plant is thus far unknown."

No experiments in the practical treatment of this pest seem to have been recorded.

The Larger Corn Stalk-borer *

Throughout the South from Maryland to Louisiana and westward to Kansas more or less serious injury is done by large white, brown-spotted caterpillars which bore into the stalks. In spring the young caterpillars bore into the heart of the young plant and like other insects with similar habits (see page 161) are known as "budworms." Later the hollowing out of the stalk so weakens the plant that it is readily broken over by the wind. Consequently a loss of from 25 to 50 per cent of the crop not infrequently results where the pest is abundant.

Life History.—When the caterpillars become full grown in the fall they burrow down into the tap-root and there pass the winter in a small cavity at or near the surface of the ground. About the time the land is being prepared for corn, from March 15 to April 30, depending on the locality, the larva changes into a reddish-brown pupa, from which the moth emerges in ten days or more. The

* *Diatraea zeacolella* Dyar. Family *Crambidae*. See Circular 139, Bureau of Entomology, U. S. Dept. of Agriculture.

moth is a brownish-yellow color with wings expanding $1\frac{1}{4}$ inches, the hind-wings being darker and bearing faint markings (Fig. 128). The eggs are laid at dusk upon the under surface of the leaves of the young corn, and hatch in from seven to ten days. The eggs are flat, scale-like, and placed in rows of from two to twenty-five, slightly overlapping each other. They are $^3/_{100}$ inch long, by two thirds as wide, at first a creamy-white, but gradually becoming a reddish brown. The young larva bores into the stalk, often destroying the "bud," and then at or near the ground, where it burrows upward in the pith, seldom damaging the stalk above the third joint. As the borers grow they become quite active and frequently leave and re-enter the stalk, thus making several holes. The caterpillars become full grown in twenty to thirty days, and are about one inch long, dirty-white, thickly covered with dark spots, each of which bears a short, dark bristle. The mature caterpillar bores outward to the surface of the stalk, making a hole for the escape of the adult moth, which it covers with silk, and then transforms to a pupa in its burrow. This occurs during July, and the moths of the second generation emerge

Fig. 126.—Work of the larger corn stalk-borer: *a*, general appearance of stalk infested by the early generation of borers; *b*, same cut open to show pupa and larval burrow. (After Howard, U. S. Dept. Agr.)

in seven to ten days. The second brood of larvæ feed on the old

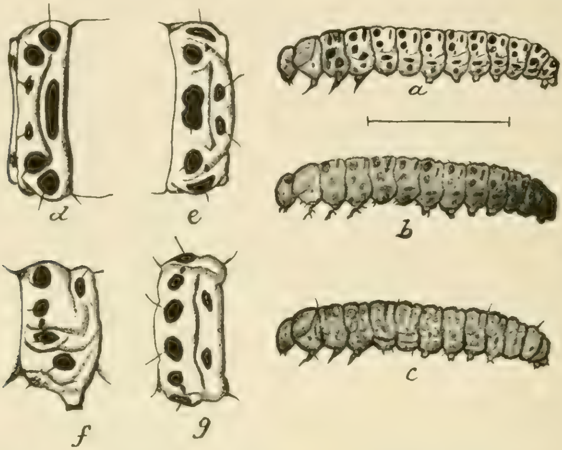


FIG. 127.—*a*, *b*, *c*, varieties of the larva of the larger corn stalk-borer; *d*, third thoracic segment; *e*, eighth abdominal segment; *f*, abdominal segment from side; *g*, same from above—enlarged. (After Howard, U. S. Dept. Agr.)

stalks, tunneling them between the second joint and the ground, and become full grown about harvest time when they go into winter quarters in the root as above described.

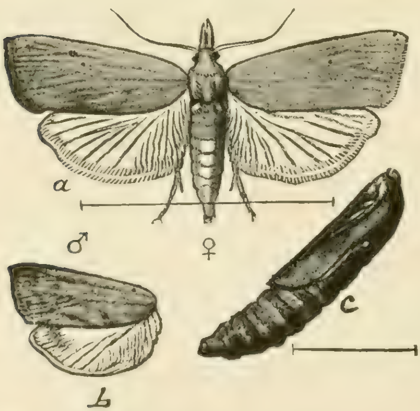


FIG. 128.—The larger corn stalk-borer. *a*, female; *b*, wings of male; *c*, pupa —all somewhat enlarged. (After Howard, U. S. Dept. Agr.)

Control.—It has been observed that late planted corn is much less injured than that planted early, but as it is more seriously injured by some other pests, late planting may not be advisable.

Where corn has been seriously injured, the old stalks or butts should be dragged off the field and burned late in the fall, thus destroying the over-wintering borers.

When corn is stripped for fodder, the stalks left standing and the land sown in small grain, the most favorable conditions are allowed the borers for safely passing the winter and developing into moths which will fly to new fields in the spring.

A simple rotation of crops will also lessen injury considerably, as Dr. L. O. Howard has observed that where fields which had been in corn the previous year were damaged 25 per cent, those planted on sod land were damaged but 10 per cent, though reasonably close to land which had been in corn.

Bill-bugs *

Throughout the South and often in the more Northern States, Canada, and the West the bill-bugs sometimes become serious enemies of young corn-plants. They are called "bill-bugs" on account of the prolongation of the head, termed a bill or snout, peculiar to all the weevils or "snout-beetles," by means of which they are enabled to drill holes in the corn-stalks. Several species belonging to the genus *Sphenophorus* are commonly injurious to corn. One of these, *S. parvulus* Gyll., also attacks small grains and timothy, and is therefore known as the Grain Sphenophorus. Another species, *S. obscurus* Boisd., does considerable injury to sugar-cane in Hawaii. The adult beetles are from one-fourth to three-fourths of an inch long, of the form shown in the illustration, and are of a brown or black color, marked with darker longitudinal ridges on the wing-covers. The larva is a thick fleshy white grub, from one-fourth to five-eighths of an inch long, with a brown head and cervical shield on the first segment, and footless.

Life History.—The life histories of the different species are but partially known.

S. parvulus hibernates over winter as a beetle, appearing in March and April. The female punctures the stalk of wheat or timothy—oats and barley are also sometimes attacked—a little above the roots, and deposits her egg in the cavity. This is done in May or June or even up to July 1st. The larvæ are to be found

* Species of *Sphenophorus*. Family *Calandridæ*. See S. A. Forbes, 23d Report of the State Entomologist of Illinois.

during July, becoming full grown and pupating during the latter part of that month. The larvæ will eat out quite a cavity in the interior of the stalk or bulb, and then attack the roots, thus often killing a whole clump or stool of small grain or timothy. The pupal stage is passed in a small cell in the earth and lasts from two

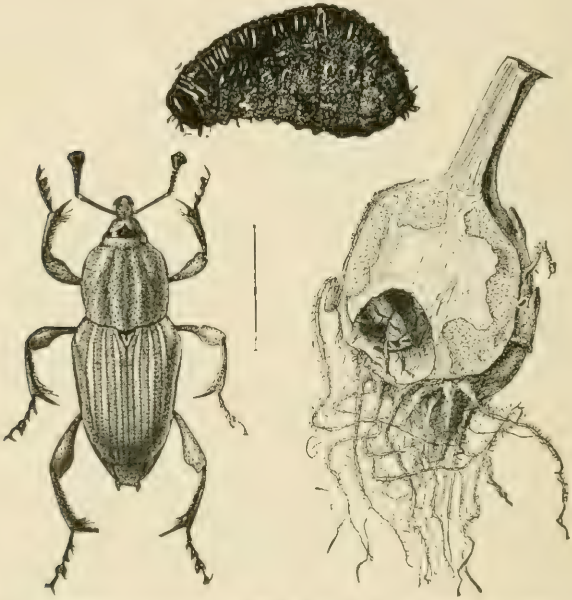


FIG. 129.—*Sphenophorus ochreus*, larva, adult, and work in roots of *Scirpus*. (After F. M. Webster, "Insect Life.")

to three weeks, adult beetles emerging from the middle of August to the first of October.

One of the most injurious species to corn is *S. ochreus* Lec. The life history is much the same as that of *S. parvulus*, though eggs have been found as late as July 30th. The natural food-plant of this species, however, is the common club-rush (*Scirpus fluviatilis*), the roots of which consist of bulbs connected by smaller slender roots. The eggs are deposited in or about the roots of this rush, never having been found on corn. The bulbs of the rush are very hard and oftentimes as large as hens' eggs. In them the

larvæ burrow, becoming full grown and transforming to pupæ, from which the adult beetles appear in August and September. When the rush becomes too hard for the beetles they often attack a common reed (*Phragmites communis*), piercing and splitting

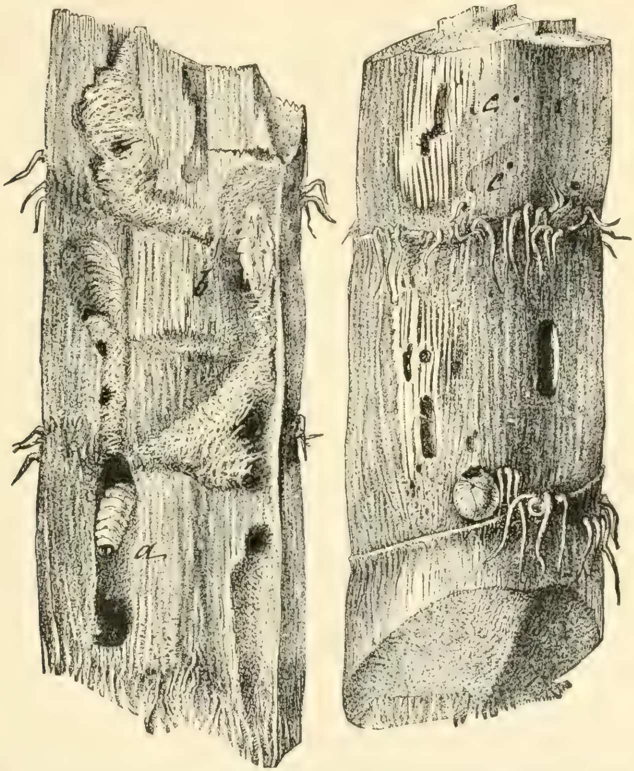


FIG. 130.—Sections of sugar-cane showing work of *Sphenophorus obscurus*. *a*, larva; *b*, pupa; *c*, probable points of oviposition. (After Riley and Howard, "Insect Life.")

lengthwise the unfolded terminal leaves, and eating out the succulent portions within. The injury to corn is done by the beetles while the corn is still young, feeding upon it in the same manner as do the other species. "Standing with the head downward and the feet embracing the lower part of the stalk," says Dr. Forbes, "they slowly sink the beak into the plant, using the jaws to make

the necessary perforation. By moving forward and backward and twisting to the right and left, the beetle will often hollow out a cavity beneath the surface much larger than the superficial injury will indicate." As the lower part of the stalk becomes hardened, they leave it for the terminal portion, and when the ears commence to form they often penetrate the husk and gorge out the soft cob. Sometimes the injury thus inflicted is but slight, merely resulting in a puncturing of the leaves when they unfold, these holes being in a series across the leaf resulting from a single puncture when the leaf was folded, and looking much like the work of the corn-root webworm; but when several beetles attack a young plant, they will either kill it outright or so deform the foliage and stalk that no ear will mature.

Several other species have also been known to do more or less injury to corn, viz., *S. scoparius, placidus, cariosus, sculptilis,* and *pertinax,* but so far as known their habits and injuries are much the same as of those already described.

Means of Control.—The control of these pests is rather a difficult task. *S. ochreus,* as in fact are all of the species, is most injurious on recently cleared swamp-lands, and usually disappears as fast as these lands are drained and cultivated. Planting flax, potatoes, or some crop not attacked by these insects for the first crop will largely prevent so serious injury to a subsequent corn crop. The burning over of grass- and swamp-lands infested with the beetles will also be of considerable value.

The Maize Bill-bug *

Throughout the Southern States and northward to Kansas there has been more or less serious injury by a bill-bug which has been recognized for many years as *Sphenophorus robustus* Horn. Recently Dr. F. H. Chittenden has recognized this insect as a new species and Mr. E. O. G. Kelly has published a complete account of its life history, from which the following is taken.

As will be seen below this species is known to pass its entire life

* *Sphenophorus maidis* Chittn., see E. O. G. Kelly, Bulletin 95, Part II, Bureau of Entomology, U. S. Dept. Agr.

history upon the corn-plant, so that the common name given it appropriately distinguishes it from the other bill-bugs previously mentioned. It has, however, been found feeding and probably breeding in swamp-grass (*Tripsacum dactyloides*), which may be its native food plant.

Life History.—The eggs were found in southern Kansas during June, laid in punctures made by the female in young corn-plants. These egg punctures are mere slits and do not seem to materially injure the plant. The eggs hatch in from seven to twelve days, and from them emerge small footless, dingy white grubs, with chestnut-brown heads, of the appearance shown in Fig. 132. "They at once begin feeding on the tissues of the young corn at the bottom of the egg puncture, directing their burrow inward and downward into the taproot. When they finish eating the tender parts of the taproot they direct their feeding upward, continuing until full grown, allowing thelower portion of the burrow to catch the frass and excrement. This burrowing of the taproot of the young growing corn-plant is disastrous to the root system; . . . allowing it to die or become more or less dwarfed." Often the young larvæ burrow into the heart of the plant and cut off the growing bud, thus killing the top. The larvæ become full grown early in August, when they are about four-fifths of an inch long. "The larvæ, on finishing their growth, descend to the lower part of the burrow, to the crown of the taproot, cutting the pith of the cornstalk into fine shreds, with which they construct a cell where they inclose themselves for pupation." The pupæ are to be found in these cells in late August and early September, the

FIG. 131.—The maize bill-bug (*Sphenophorus maidis* Chittn.)—four times natural size. (After Kelly, U. S. Dept. Agr.)

pupal stage lasting ten to twelve days. The adults commence to emerge by the middle of August and continue to do so until the middle of September. "Some of them leave the pupal cells, but most of them remain there for hibernation." Those which emerged disappeared and probably hibernated in some dense, coarse grass near by. Those which hibernated in the pupal cells emerged the next spring about the time that young corn was sprouting. The beetles are from two-fifths to three-fifths of an inch long, of a dull shining black color, and sculptured as shown in Fig. 131. "The beetles are rarely observed on account of their

FIG. 132.—Larva of the maize bill-bug—twice natural size. (After Kelly, U. S. Dept. Agr.)

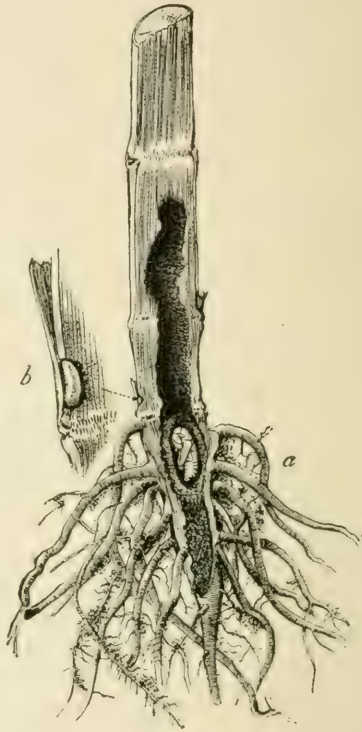


FIG. 133.—Corn plant showing the result of attack of the maize bill-bug: *a*, larval burrow containing pupa in natural position—reduced two-thirds; *b*, egg-puncture containing egg — enlarged. (After Kelly, U. S. Dept. Agr.)

quiet habits and because they are covered with mud—a condition which is more or less common among several species of this genus and which is caused by a waxy exudation of the elytra to which the soil adheres. The presence of the adults of this species in a cornfield is made evident by the withering of the top leaves of very

young corn-plants, the plants having been severely gouged. After the plants grow 10 to 15 inches tall they do not kill them, but gouge out such large cavities in the stalks that they become twisted into all sorts of shapes. The attacked plants sucker profusely, affording the young, tender growth for the beetles to feed upon, even for many days after the non-infested plants have become hard." Injury seems to be most serious on low land. Injury by this species somewhat resembles that done by the larger corn stalk-borer (*Diatraea zeacolella*), but is easily distinguished from the work of the other bill-bugs, as the punctures of the latter, which usually form a row or rows of holes in the leaves when they unfold, are not always fatal to the plants.

Control.—Inasmuch as most of the beetles hibernate in the corn stubble, they may be readily destroyed by pulling out and burning the stubble. Care must be taken, however, to pull out the taproot, as the stalk will be liable to break above the beetle and leave it in the ground. As the infested stalks have a poor root system, they are easily pulled.

The Corn Ear-worm *

Practically the only insect injuring the ears of field-corn and the worst insect pest of sugar-corn, is the ear-worm. In the extreme South it is almost impossible to grow sugar-corn successfully on account of its injury, while further north it largely reduces the profits of corn grown for the cannery, and destroys a considerable percentage of the kernels of field-corn. It is a most cosmopolitan insect, being found throughout the United States and in many parts of the world, and has a long list of food plants, being known as the tomato fruit-worm, tobacco bud-worm, and cotton boll-worm (see pages 304, 234, 254) when attacking these plants, besides which it feeds on beans, peas, and many garden crops and forage plants, such as cowpeas and alfalfa.

Life History. Along the Gulf Coast the first moths appear in April, in the latitude of 33° about the middle of May, and in the latitude of Delaware and Kansas, early in June.

* ***Heliothis obsoleta*** Fab. Family *Noctuidæ.*

The moth is about three-quarters of an inch long with a wing expanse of about $1\frac{3}{5}$ inches and is extremely variable in color and markings. Some are dull olive green while others are yellowish or nearly white and with almost no markings. In the most typical moths the wings are bordered with dark bands, the wing veins are black and the fore-wings are spotted with black.

FIG. 134.—Corn ear-worms at work. The central cob has been attacked by a nearly full-grown worm, which has bored through the husk near the middle.

The eggs are semispherical in shape, about one-fifteenth inch in diameter, light yellowish, and prettily corrugated with ridges as shown in Fig. 184. Those of the first brood are laid on corn, peas, beans, or whatever food-plants are available, and hatch in three to five days, depending upon the temperature.

The caterpillars of the first generation often attack corn when about knee-high, feeding in the axils of the tender leaves, so that

when the leaves unroll they bear horizontal rows of holes. The caterpillars are exceedingly variable in color, being from a light green through rose color and brown to almost black, and either

FIG. 135.—Corn ear-worm. Husk of ear of sugar-corn torn open, showing worms at work on tip and hole through which a full grown worm has left.

striped, spotted or perfectly plain. They become full grown in about $2\frac{1}{2}$ weeks and are then about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long. When done feeding the caterpillar burrows 2 to 5 inches into the soil near the base of the plant. A cell is then constructed which runs back to within a half inch of the surface of the soil, so that the

moth may readily push off this surface soil and escape. The burrow finished, the larva retires to the bottom of the cell and there molts and enters the pupal stage.

The pupa is four-fifths inch long, shining reddish-brown. During the summer the moths emerge about two weeks later, but the last generation in the fall passes the winter in the pupal stage. Thus the complete life cycle from egg to adult moth requires slightly over a month in midsummer, and from six to eight weeks for the spring and fall broods.

The second generation of moths appears about the middle of July in the latitude of Delaware and Kansas. In the far South the second generation of moths appears when corn is coming into silk and tassel, upon which the moths always prefer to lay their eggs. As a result, the caterpillars of the second generation in the South, and the third further North, do serious injury to field-corn, gnawing out the kernels at the tips of the ears, and furnishing favorable conditions for molds to propagate, which do further injury. From 2 to 3 per cent of the corn crop of the country, with a cash value of \$30,000,000 to \$50,000,000, is thus destroyed by the ear worm annually.

The third generation of moths appears the last of August in Delaware and Kansas and gives rise to the third brood of caterpillars, which are there the most destructive brood on field-corn and sugar-corn, frequently causing a loss of from 10 to 50 per cent of the latter crop. The caterpillars become full grown during the latter part of September and change to pupæ, which hibernate over winter as already described.

In the Gulf States there are four full broods and along the Gulf Coast there may be five or six, while in the Northern States there are but two generations, with possibly but one in Ontario.

Control. As the pupæ pass the winter in the soil, by all means the most satisfactory and practical means of control is to plow infested land in late fall or during the winter, plowing deeply and harrowing. This will break up the pupal cells, crush some of the pupæ, and expose others to the rigors of winter to which most of them will succumb.

The early planting of field-corn prevents the moths from laying their eggs upon it, as it will have passed the silking stage and other fields which are in silk will be preferred; it being possible to thus reduce the injury by at least a third by early planting.

Where the caterpillars of the first generation are working in the unfolding leaves, they are sometimes poisoned with Paris green, mixed with flour or corn meal as used for this pest on tobacco, but as Paris green often burns the foliage powdered arsenate of lead will doubtless be found equally effective without burning.

CHAPTER X

INSECTS INJURIOUS TO STORED GRAINS *

The farmer who stores his grain, awaiting a higher price, is sometimes sadly disappointed to find that it has been so riddled by "weevil" that it brings no more than had it been sold previously.

The term "weevil" is rather a comprehensive one, being commonly applied to almost every insect infesting stored food-products. Only a few species are commonly injurious in the farm-granary.

Grain-weevils

Of these the Granary-weevil † and the Rice-weevil ‡ (Fig. 136), are the most common and widely distributed. Both of these insects have infested grain from the most ancient times, so long, in fact, that the granary-weevil has lost the use of its wings and remains entirely indoors. They are small, brown beetles, from one-eighth to one-sixth of an inch in length, with long snouts which are of great service in boring into the kernels of grain. By means of them the females puncture the grain and then insert an egg in the cavity. The larva hatching from this is without legs, somewhat shorter than the adult, white in color, and of a very robust build, being almost as broad as long. It soon devours the soft interior of the kernel and then changes to a pupa, from which the adult beetle emerges in about six weeks from the time the egg was laid.

Only a single larva inhabits a kernel of wheat, but several

* See "Some Insects Injurious to Stored Grains," F. H. Chittenden, Farmers' Bulletin, 45, U. S. Department of Agriculture.

† *Calandra granaria* Linn.

‡ *Calandra oryzæ* Linn. Family *Calandridæ*.

will often be found in that of corn. Not only do the larvæ injure the grain, but the beetles feed upon it, and then hollow out a shelter for themselves within the hull. The beetles are quite long-lived, and thus do considerable damage. The egg-laying period is equally long, and as there are three or four broods in the North and six or more in the South, it has been estimated that the progeny of one pair would amount to 6000 insects in a single season.

Grain-beetles

Another beetle very common in the granary, but of quite different appearance, is the Saw-toothed Grain-beetle * (Fig. 137). It is a cosmopolitan pest and is also nearly omnivorous. The beetle is only about one-tenth of an inch long, very much flattened, of a dark-brown color, and may be easily recognized by the six saw-like teeth on each side of the thorax. The larva is of a dirty-white color, and quite dissimilar from that of the granary weevil. Having six legs to carry it about, it is not satisfied with a single seed, but runs about here and there, nibbling at several. When full grown the larva glues together several grains or fragments into a little case, and inside of this transforms to the pupa and then to the beetle. In early spring this life

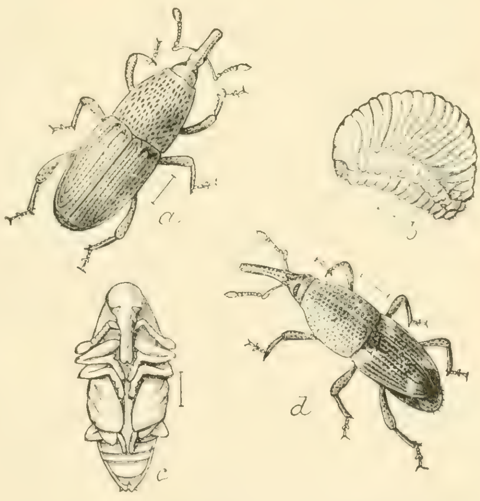


FIG. 136.—The grain weevil (*Calandra granaria*): *a*, beetle; *b*, larva; *c*, pupa, *d*, the rice weevil (*C. oryzæ*): beetle—all enlarged. (After Chittenden; U. S. Dept. Agr.)

* *Silvanus surinamensis* Linn. Family *Cucujidæ*.

cycle requires from six to ten weeks, but in summer it is reduced to about twenty-five days. Thus there are from three to six or more generations during a season, according to the latitude.

The Red or Square-necked Grain-beetle * is about the same size as the last species, but is of a reddish-brown color, and the thorax is almost square, nearly as broad as the abdomen, and not notched on the sides. It breeds in corn in the field and in the granary, first destroying the germ, so that it is especially

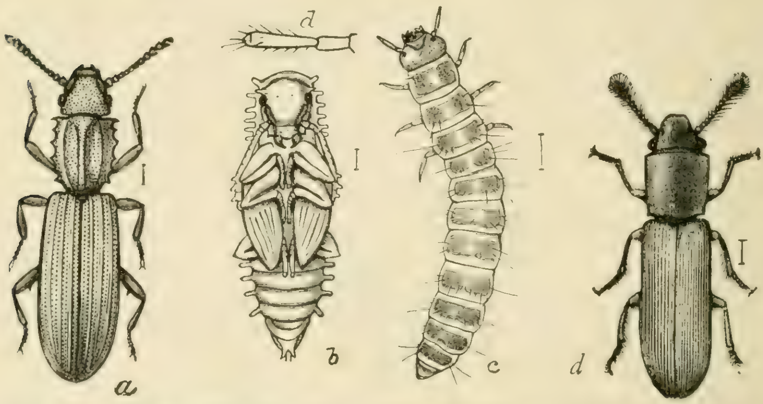


Fig. 137.—The saw-toothed grain beetle (*Silvanus surinamensis*): *a*, adult beetle; *b*, pupa; *c*, larva—all enlarged; *d*, antenna of larva—still more enlarged; *d*, the red or square-necked grain beetle (*Cathartus gemellatus* Duv.) (After Chittenden, U. S. Dept. Agr.)

injurious to seed-corn. It feeds mostly out of doors, though sometimes infesting the granary.

The Foreign Grain-beetle † is of much the same general appearance, but smaller and of a more robust appearance It feeds upon a great variety of stored products as well as grain, but rarely becomes troublesome.

The Cadelle ‡ also has the bad habit of first attacking the embryo or germ of the kernel, and going from one kernel to another, thus destroys a large number for seed purposes. It possesses,

* *Cathartus gemellatus* Duv.
† *Cathartus advena* Waltl.
‡ *Tenebroides mauritanicus* Linn. Family *Trogositidæ*.

however, the good trait of feeding on other injurious grain-insects. The beetle is oblong, flat, nearly black, and about one-third of an inch long. The larva is of a whitish color, with a

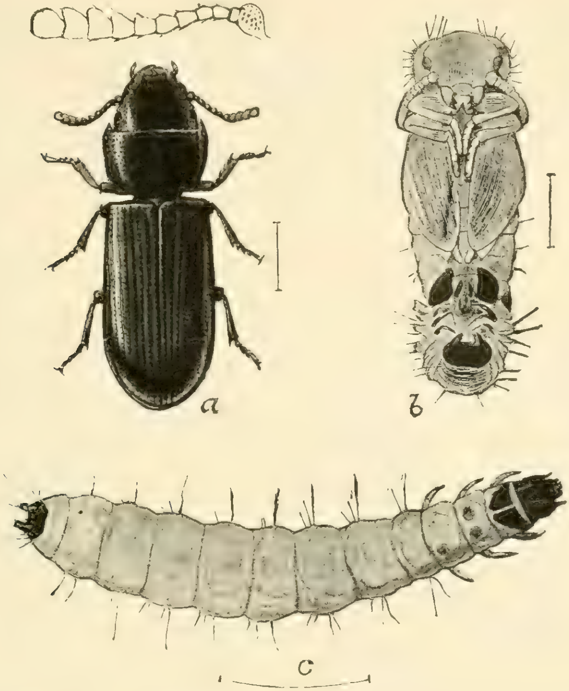


FIG. 138.—The Cadelle (*Tenebroides mauritanicus*): *a*, adult beetle with greatly enlarged antenna above; *b*, pupa; *c*, larva—all enlarged. (After Chittenden, U. S. Dept. Agr.)

brown head, the thoracic segments are marked with brown, and the abdomen terminates in two dark horny processes. It is a fleshy grub, nearly three-fourths of an inch long when full grown.

Flour- and Meal-moths

The larvæ of several small moths sometimes infest grain in store, but rarely do it serious damage, preferring the softer flour, meal, and food-products.

The most destructive of these is the Mediterranean Flour-

moth * (Fig. 139). This insect was practically unknown until 1877, but during recent years it has occasioned the loss of many thousands of dollars to mill-owners. It occurs throughout

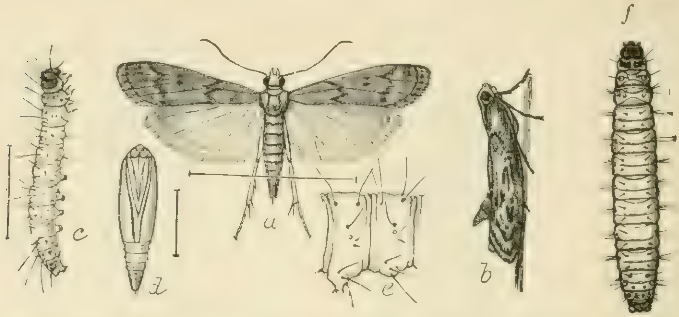


FIG. 139.—The Mediterranean flour-moth (*Ephestia kuehniella*): *a*, moth; *b*, same from side, resting; *c*, larva; *d*, pupa—enlarged; *e*, abdominal joint of larva—more enlarged; *f*, larva, dorsal view. (After Chittenden U. S. Dept. Agr.)

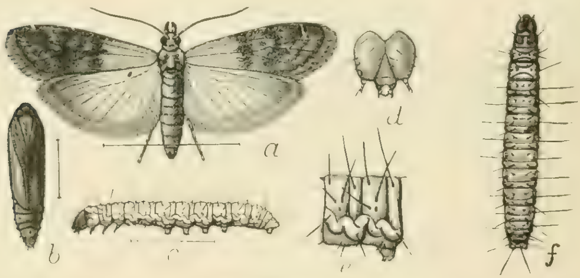


FIG. 140.—The Indian meal-moth (*Plodia interpunctella*): *a*, moth; *b*, pupa; *c*, caterpillar; *f*, same, dorsal view—somewhat enlarged; *d*, head, and *e*, first abdominal segment of caterpillar—more enlarged. (After Chittenden, U. S. Dept. Agr.)

Europe, and is found in Mexico and Chili. It was first recognized in America in 1889, and has since done an increasing amount of damage in California, in New York and Pennsylvania, North Carolina, Alabama, New Mexico, and Colorado, and has become

* *Ephestia kuehniella* Zell. Family *Pyralidæ*. See W. G. Johnson, Appendix 19th Report State Entomologist of Illinois, and F. L. Washburn, Special Report of the State Entomologist of Minnesota on the Mediterranean flour-moth.

quite generally distributed. "The caterpillars form cylindrical silken tubes in which they feed, and it is in great part their habit of web-spinning that renders them so injurious where they obtain a foothold. Upon attaining full growth the caterpillar leaves its original silken domicile and forms a new web, which becomes a cocoon in which to undergo its transformations to pupa and imago. It is while searching for a suitable place for transformation that the insect is most troublesome. The infested flour becomes felted together and lumpy, the machinery becomes clogged, necessitating frequent and prolonged stoppage, and resulting in a short time in the loss of thousands of dollars in large establishments."

FIG. 141.—The meal snout-moth (*Pyralis farinalis*): *a*, adult moth; *b*, larva; *c*, pupa in cocoon—twice natural size. (After Chittenden, U. S. D. Agr.)

The life cycle of this insect requires ordinarily about two months, but may be completed in thirty-eight days under the most favorable conditions. The adult moth measures a little less than an inch across the expanded wings. The fore-wings are of a lead-gray color, with transverse black markings, while the hind-wings are dirty whitish, with a darker border.

The Indian Meal-moth * (Fig. 140) larvæ resemble those of the grain-beetles in having a special liking for the embryo of wheat-grains. They spin a fine silken web as they go from seed to seed, to which they become attached, and to which is added a large amount of excrement, thus spoiling for food much more grain than is actually injured.

The moth has a wing-expanse of an inch; the inner third of the fore-wings being a whitish gray, and the outer portion reddish-brown, with a coppery lustre.

* *Plodia interpunctella* Hbn. Family *Pyralidæ*.

The Meal Snout-moth * (Fig. 141) is of a light brown color, the thorax, base, and tips of the fore-wings being darker brown. The wings expand nearly an inch and are otherwise marked with whitish lines as shown in the figure. It is very similar to the last-mentioned species in its habits, constructing long tubes with silk and particles of the food in which it is living. The life-history is completed in about eight weeks, and four generations may occur in a year. The moisture of "heated" grain is most favorable for the development of this pest, and it need not be feared if grain is kept in a clean, dry place.

The Angumois Grain-moth †

By far the worst granary pest throughout the South is the "fly-weevil," or Angumois grain-moth.

History.—This insect is an importation from Europe and receives its name from the fact that in 1760 it "was found to swarm in all the wheat-fields and granaries of Angumois and of the neighboring provinces [of France], the afflicted inhabitants being thereby deprived of their principal staple, and threatened with famine and pestilence from want of wholesome bread." The insect was first noted in this country in North Carolina in 1730, and in 1796 was so abundant as to extinguish a lighted candle when a granary was entered at night. It is essentially a southern insect, being very injurious to stored corn in the Gulf States. Of late years it seems to be moving steadily northward, being reported as injurious in central Pennsylvania and Ohio. Wheat, corn, oats, rye, barley, sorghum-seed, and even cow-peas are subject to injury.

Life History.—The injury is not done by the moth, as might be reasonably supposed from the fact that it is the only form of the insect usually seen, but is done by the small caterpillars which feed within the grain, where they may be found during the winter. The caterpillar eats to the surface of the kernel, but not through it, thus leaving a thin lid which the moth can

* *Pyralis farinalis* Linn. Family *Pyralidæ*.
† *Sitotroga cerealella* Oliv. Family *Gelechiidæ*.

easily push aside when it comes out in the spring, and then covers itself with a fine silken web. At this time the caterpillar is usually fully grown and is about one-fifth of an inch long, of a white color, with the head yellowish and harder, and having six jointed legs in front, a series of four pairs of fleshy pro-legs along the middle, and another pair of soft legs at the end of the body. With warm spring weather the caterpillar changes to a pupa, and about the time that the wheat comes into head the adult moth emerges. As soon as it emerges, whether outdoors or in a

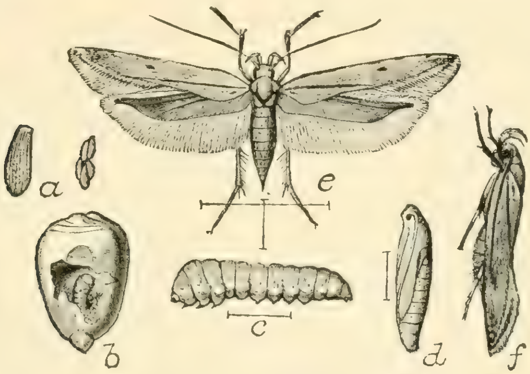


FIG. 142.—The Angumois grain-moth (*Sitotroga cerealella*): *a*, eggs; *b*, larva at work; *c*, larva, side view; *d*, pupa; *e*, moth; *f*, same, side view. (After Chittenden, U. S. Dept. Agr.)

barn, the moth at once flies to the grain-field, where the eggs are deposited. The exact time at which the moths emerge varies, but occurs some time late in May or in June. The moths quite closely resemble the clothes-moth often found flying about houses. The wings are quite narrow, and when expanded measure about one-half an inch from tip to tip, being of a yellowish or buff color, marked with black. The eggs are laid in the longitudinal channel on the side of the grain. Each female lays from sixty to ninety eggs in lots of about twenty each, one lot thus being about enough to infest the kernels of a head. The eggs hatch in from four to seven days. The young caterpillars are at first very active and soon find tender places and bore into the kernels, leaving

almost invisible openings. These caterpillars become full grown in about three weeks, just about the time the grain is mature. About harvest-time the second brood of moths appears. These lay their eggs during July, depositing them on the ripe heads if the harvest be a little delayed, but on the wheat in stack if harvest is prompt. Usually the caterpillars hatching from these eggs become full grown and remain in the grain over winter, but in warm seasons, especially if warm in September or when the pest is unusually abundant, a third brood of moths appears early in September. These lay another batch of eggs about the middle of September, depositing them upon the open ends of grain in stack or mow, which thus becomes more infested than that in the centre. In grain stacked outside, the caterpillars of this brood become full grown slowly and remain in the grain over winter, but if in the barn they grow faster and a fourth brood of moths appears about the middle of October, the moths being noticed in threshing. The insects continue to breed within doors all winter as long as any grain remains, though they become sluggish and cease feeding during cold weather. The number of broods is entirely dependent upon the latitude and weather conditions; in the South, where they can breed continuously, there being as many as eight in a year.

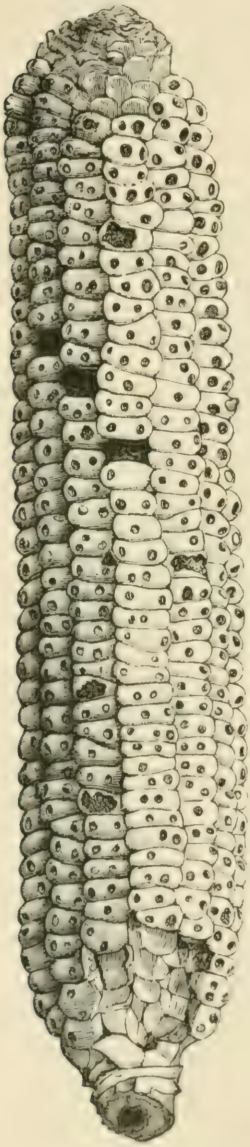


FIG. 143.—Ear of pop-corn, showing work of Angumois grain-moth. (After Riley.)

Corn is frequently attacked, but not until it is ripe and husked, and then but rarely when husked in October and November and stored outdoors in slatted cribs. Seed-corn stored in barns, and in the South in almost any situation, is often badly injured.

Aside from the loss in weight, grain when badly infested becomes unfit for milling purposes, and will even be refused by cattle and horses, which should not be urged to eat it, though hogs and fowls will readily consume it.

Remedies.—Dr. J. B. Smith, in an interesting bulletin upon this pest, to which we are indebted for much of the above, advises as follows: "Thresh as soon after harvest as possible, and bulk in tight bins or in good sacks. [By "tight bins" are meant those which will not permit the entrance or exit of the moths.] If the grain is dry when harvested, it may be threshed at once; if not, as soon as it is in good condition. If the sacked grain is infested, there will not be wormy kernels sufficient to heat the grain. The moths cannot make their way out and are stifled. Nothing can come in from outside and the grain remains safe. The threshing itself kills many of the insects and jars and rubs off many of the eggs. If binned, the bins should be *tight* and the grain should be tested occasionally for any appreciable heating. If it heats perceptibly, it indicates considerable infestation, and it should be treated with carbon bisulfide at once, used at the rate of one drachm per cubic foot, or 1 pound for 250 cubic feet bin-space." Recent investigations have shown that more bisulfide will often be necessary. See page 198.

Those having wheat unthreshed, whether in stack or mow, should thresh at once, and treat as above directed, except that if much of it is noticed to be wormy, it should be treated with carbon bisulfide at once, as soon as threshed, which if done thoroughly will prevent any further infestation that year.

Barns and storehouses should be cleaned up and freed from all loose and scattered grain—chickens will help in this—before April 1st, so that no moths will be allowed to develop and infest the grain in the field. Places where grain has been in shock the previous season should be cleaned up by the aid of chickens. Thus if

there is any probability of grain being infested, it should be kept tightly covered in the spring so as not to permit the spread of the moths to the fields.

Prevention of "Weevil"

Undoubtedly grain-insects can usually be more successfully combated by a proper housing of the grain. No matter how often the insects are destroyed in a granary, if the remainder of the barn is full of dust, sweepings, and refuse, as it generally is, on which the beetles can feed and in which they will breed, and if the granary is not absolutely tight, as soon as the gas passes off the insects from the barn will again enter the granary, and soon it will be as badly infested as ever.

Cleanliness.—"Cleanliness will accomplish much toward the prevention of injury from these pests, the cause of a great proportion of injuries in granaries, mills, elevators, and other structures where grain and feed are stored being directly traceable to a disregard of neatness. Dust, dirt, rubbish, and refuse material containing sweepings of grain, flour, and meal are too frequently permitted to accumulate and serve as breeding-places for a multitude of injurious insects.

"The floors or corners and walls of the barn or storehouse should be frequently swept, and all material that has no commercial value burned."

The Granary.—"The ideal farmer's granary, from the standpoint of insect ravages, should be built at some distance from other buildings, and the rooms constructed of matched floorings so as to be as near vermin-proof as possible. The doors should fit tightly, closing upon a rabbet, which may be covered with felt or packing, and the windows covered with frames of wire gauze to prevent the passage of insects. The floor, walls, and ceilings should be smooth, so as not to afford any lurking-places for the insects, and it would be well to have them oiled, painted, or whitewashed for further security. A coating of coal-tar has been strongly recommended for the latter purpose."

"The value of a cool place as a respository of grain has been

known of old, and a building in which any artificial heat is employed is undesirable for grain storage. The 'heating' and fermentation of grain, as is well known, is productive of 'weevil,' and this should be prevented by avoiding moisture and by ventilation.

"*The storage of grain in large bulk* is to be commended, as the surface layers only are exposed to infestation. This practice is particularly valuable against the moths, which do not penetrate far beneath the surface. Frequent agitation of the grain is also destructive to the moths, as they are unable to extricate themselves from a large mass, and perish in the attempt. The true granary-weevils (small dark-brown beetles with long curved snouts, similar to the pea-weevil), however, penetrate more deeply, and although bulking is of value against them, it is not advisable to stir the grain, as it merely distributes them more thoroughly through the mass."—Chittenden.

Destruction of "Weevil"

Carbon Bisulfide.—"The simplest, most effective, and most inexpensive remedy for all insects that affect stored grain and other stored products is the bisulfide of carbon, a colorless liquid, with a strong disagreeable odor, which, however, soon passes away." At ordinary temperatures it vaporizes rapidly, forming a heavy gas, which is highly inflammable and a powerful poison.

Application.—It may be applied directly to the infested grain or seed without injury to its edibleness or viability by spraying with an ordinary watering-can having a fine rose nozzle. In moderately tight bins it is more effective, however, as it evaporates more slowly and diffuses more evenly, if placed in shallow dishes or pans, or on bits of cloth or cotton waste distributed about on the surface of the grain or infested material. The liquid volatilizes rapidly, and, being heavier than air, descends and permeates the mass of grain, killing all insects and other vermin present. The bin should then be covered with boards, canvas, or blankets, and allowed to remain at least twenty-four hours. If to be used for seed, it should not be left for over thirty-six hours; but if not,

leave it forty-eight hours, which will do it no injury for food. After treating, keep the grain covered to prevent reinfestation.

Amount to Use.—It was formerly recommended that the bisulfide be applied at the rate of 1 to 3 pounds to 100 bushels of grain or 1000 cubic feet of open space. Recent experiments, however, have shown the total inadequacy of this dosage. Experiments made by Hinds and Hunter * show that the effectiveness of the gas is in direct proportion to the temperature. Below 60° F. the fumigation is ineffective and inadvisable. A dosage which will kill practically all the weevil at 67° to 70° will kill but 60 to 70 per cent at 60° to 65°. They recommend the use of 5 pounds per 1000 cubic feet where the room or bin is quite tight and the temperature is 70° or above. For loose rooms and lower temperatures, the dosage must be largely increased and may not be profitable. The above estimates are based upon the grain being in a cubical shape; if it is spread out shallow, more bisulfide will be necessary.

Caution.—"Certain precautions should always be observed. The vapor of carbon bisulfide is deadly to all forms of animal life if inhaled in sufficient quantity, but there is no danger in inhaling a small amount. The vapor is highly inflammable, but with proper care that no fire of any kind, as, for example, a lighted cigar, lantern, or light of any kind, be brought into the vicinity until the fumes have entirely passed away, no trouble will be experienced."

Hydrocyanic Acid Gas.—Mills and storehouses which needed treatment were formerly fumigated with carbon bisulfide, which is still employed to a considerable extent, but this has been largely replaced by fumigation with hydrocyanic acid gas, which obviates the risk from fire. Directions for the use of this gas should be obtained from the entomologist of the State experiment station or from the Bureau of Entomology of the U. S. Department of Agriculture.

Sulfur Fumes.—Professor R. I. Smith (l.c) has made experi-

* Hinds and Hunter, Journal of Economic Entomology, Vol. III, p. 47: R. I. Smith, Bulletin 203, N. C. Agr. Exp. Sta.

ments with sulfur dioxid, produced by burning sulfur slightly wet with alcohol, and finds that it will effectively kill grain insects but injures the germinating power of the grain. "It was found that the fumes produced by burning 2½ pounds of sulfur either in a moist or dry atmosphere of 1000 cubic feet space, for twenty hours, would kill all exposed adult insects and practically all the young stages in the grain, but that this also destroyed its germinating power. . . While this treatment cannot be recommended for general fumigation, there is no doubt of its being the easiest and cheapest method of fumigating corn cribs, granaries and similar places whenever they are being cleaned out and freed of insects in preparation for the reception of more grain."

Heat.—The heating of grain was one of the earliest means known of combating grain insects, but has been little used in this country. Recently, however, Mr. Geo. A. Dean of the Kansas Agricultural Experiment Station,* has shown that by superheating mills they may be rid of insect pests much more quickly and cheaply than by fumigation, and with no risk from fire, or from cyanide poisoning. His experiments show that if the temperature surrounding an insect be maintained above 120° F., with a normal amount of moisture, that in a very few minutes it will be killed. This promises to become one of the most practicable methods of cleaning mills and may be used for small quantities of grain, where there are facilities for heating it or placing it in a superheated room, but probably carbon bisulfide fumigation will be found more practicable for small amounts.

* Geo. A. Dean, Journal of Economic Entomology, Vol. IV, p. 142.

CHAPTER XI

INSECTS INJURIOUS TO CLOVER *

The Clover Root-borer †

The clover root-borer is practically the only insect pest which seriously injures clover roots. It has long been known as a clover pest in Europe, but was first noticed in this country in

a b c

Fig. 144.—The clover root-borer (*Hylastinus obscurus*): *a*, adult, natural size at right; *b*, larva or grub; *c*, pupa—much enlarged. (After Webster, U. S. Dept. Agr.)

western New York in 1876, whence it has spread southward to West Virginia and westward to Illinois and southern Michigan, and has also been injurious in Oregon.

Life History.—During the winter the beetles may be found hibernating in their burrows in infested clover roots. They are not readily distinguishable, for they are scarcely one-eighth inch long, and are of a reddish-brown color much like that of the burrow. With the warmer weather of spring they commence

* See The Insect Pests of Clover and Alfalfa, J. W. Folsom, 25th Report of the State Entomologist of Illinois, p.p. 41–124.

† *Hylastinus obscurus* Marsham. Family *Scolytidæ*.

burrowing and feeding in the roots, and during late May and early June the females deposit their eggs along the sides of the tunnels. "The female gouges out a shallow cavity, more often in the crown of the plant, sometimes at the sides of the root even 2 or 3 inches below the crown, and in this places, singly, but not far separated, about a half dozen pale whitish, elliptical, very minute eggs. These hatch in about a week, and the larvæ for a time feed in the excavation made by the mother, but soon burrow downward into the root, and before the 1st of August, the majority of them have become full-grown, and passed into the pupal stage. By October nearly all have become fully developed beetles, but they make no attempt to leave the plant until the following spring." The spread of the insect occurs very largely in the spring when the beetles fly from field to field, seeking uninfested plants in which to perpetuate their kind.

Fig. 145.—Clover root, showing work of clover root-borer. Slightly enlarged. (After Webster, U. S. D. Agr.)

It has been observed that alsike clover is not so badly injured as the mammoth and common red clover, on account of the fibrous roots and the tendency of its tap-root to divide. In Europe alfalfa is injured, but no injury has yet been reported to that crop in this country, though it may be anticipated.

"While an infested clover plant sooner or later succumbs to an attack by this insect, life may be lengthened or shortened by meteorological conditions. Thus, if the spring or early summer is very dry, the plants begin to dry in patches late in June, as soon as the hay crop is removed; but if there is much rain dur-

ing this period, the weakened plants may continue to live until winter, dying out before spring. In either case the farmer is likely to be misled and attribute the loss to the weather."* Clover is practically exempt from attack the first year as the roots are not large enough to accommodate the insects, and it is not until the second year that the plants are destroyed.

Control. The only effective means of control suggested is summer following as soon as the hay crop has been removed. The field should then be plowed up at once, before the larvæ have transformed to pupæ, so that the hot sun, and dry winds, will dry out the roots of the clover and thus starve the larvæ, thereby preventing their developing and migrating to other fields. Clover fields should not be allowed to stand over two years in infested localities. No injury seems to be done in pastures. A system of rotation in which the crop is mowed for hay and seed the first year, and pastured and then broken up the second year, should keep the pest under control.

The Clover Stem-borer †

Early in June one frequently finds the beetles of the Clover Stem-borer here and there in the clover-field. They are slender, shining beetles, about one-third of an inch long, with a red head and thorax and bluish-black wing-covers. The beetles themselves seem to do little or no harm. Hibernating over winter, they lay eggs

FIG. 146.—Clover stem-borer (*Languria mozardi*): the eggs natural size and magnified, the beetle, larva, and pupa—all much enlarged, and above, a clover-stem with the larva at work in it. (After Comstock.)

* Quotations from F. M. Webster, The Clover-root Borer, Circular 119, Bureau of Entomology, U. S. Dept. Agr.

† *Languria mozardi* Fab. Family *Erotylidæ*.

in the pith of the stems early in June, and the larvæ emerging from these feed upon the pith of the stem, often very seriously weakening or killing it. The larvæ become full-grown in a short time, transform to pupæ, and the beetles appear by August.

Clover is only one of a dozen food-plants of this insect, which is widely distributed. It rarely does any considerable injury where clover is regularly cut in early summer and fall, and need not be feared when this is not neglected.

The Clover Leaf-weevil *

The clover leaf-weevil is a stout, oval beetle, about one-third inch long, with a long, thick snout. It is of a brownish color, with several narrow gray lines above and broad gray stripes on each side, and with twenty rows of small, deep punctures on the wing-covers. It is also a native of Europe and made its first appearance in the same section of western New York as the last species, about 1881. Since then it has spread eastward to Rhode Island and Vermont, southward to North Carolina and West Virginia, and westward to Wisconsin and Illinois. Every few years the weevils and their larvæ destroy much of the foliage in restricted localities, but rarely are they very injurious the next season. Red clover, alfalfa, and white clover are preferred in the order named; in Illinois the mammoth and alsike are also eaten.

Life History.—In early fall the female beetles lay their eggs in crevices among the stems near the base of the plant, which hatch in from three to six weeks. The young larvæ which hatch from them are without legs, but manage to climb by means of the prominent tubercles on the lower surface of the body. They are light yellowish-green, becoming deeper green as they grow older, the head is brown, and down the middle of the back is a white or pale yellow stripe bordered with reddish. The larvæ become partially grown before winter sets in, when they hibernate in rubbish or just under the soil until spring, when they continue to feed upon the foliage and become full-grown

* *Phytonomus punctatus* Fab. Family *Curculionidæ*.

in May and early June. They feed mostly at night and are hardly noticeable in the day, when they lie protected around the base of the plant, lying curled up head to tail. The injury to the foliage is quite characteristic, the edges of the leaves being eaten in a regular manner as shown in Fig. 147. When full grown

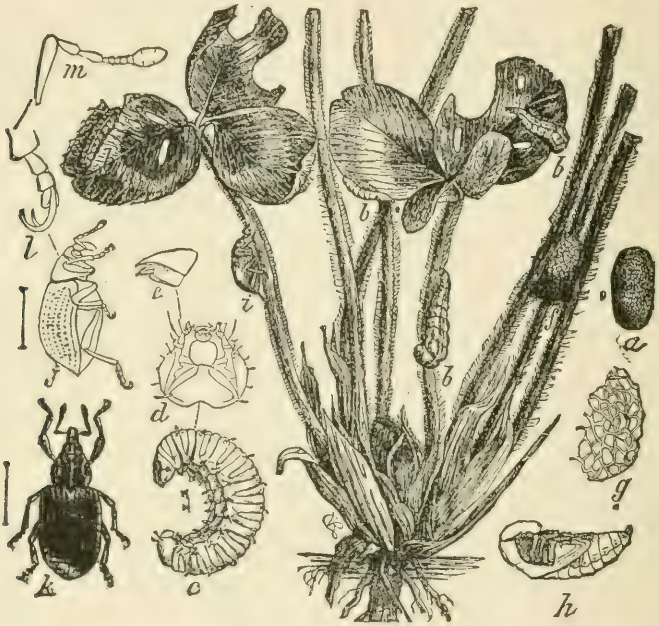


FIG. 147. Clover leaf-weevil (*Phytonomus punctatus* Fabr.): *a*, egg magnified and natural size; *b b b b*, larvæ; *c*, recently hatched larva; *d*, head of larva; *e*, jaws of the same; *f*, cocoon; *g*, same magnified to show the meshes; *h*, pupa; *i*, weevil, natural size; *j*, the same magnified; *k*, top view of the beetle; *l*, tarsus and claws of the beetle; *m*, antenna of the beetle. (After Riley.)

the larva buries itself just under the surface of the soil and makes an oval cell, in which it spins a delicate cocoon consisting of a coarse network of pale yellow threads, which later turn brown, as shown in Fig. 147. Occasionally the cocoon is made on the surface or among the bases of the stems. In this the pupal stage is passed, lasting two or three weeks; the beetles being most common in July and August. The damage which the

beetles do to the second crop of clover is fully equal that done by the larvæ to the first, and is more apparent because the soil is then dry and the plant grows more slowly.

That this insect has not become a more serious pest is due to the fact that as often as it becomes excessively abundant the larvæ are almost completely destroyed by a fungous disease.* When affected by this disease the larvæ climb to the top of a blade of grass, curl tightly around the tip, and soon die, first becoming covered with a white mold and then turning to a jelly-like mass. The spores of the fungus become scattered to healthy individuals, which soon succumb, so that before long nearly all are destroyed, and rarely do enough survive to cause trouble the next year.

Control. On account of this disease repeated injury has been so rare that no means of artificial control has been necessary. "The necessity for the employment of any remedy does not appear until the clover is well on in its second year's growth," says Dr. Folsom (l.c.). "If damage is anticipated, however, it would seem advisable to pasture the clover lightly or to clip back in the spring; this does not hurt the clover, is highly desirable as a means of forestalling the attacks of some other clover pests (see page 214), and might check the larvæ of the leaf-weevil somewhat, though it is possible that they would subsist on the cut stems until the new growth started; and in cold weather they can live a long time without any food. After the second season red clover should be plowed under to get rid of this pest, as well as for other agricultural reasons."

The Alfalfa Weevil *

In recent years a first cousin of the last species has been introduced into Utah, where it has become firmly established and promises to become the most serious obstacle to alfalfa culture. The alfalfa weevil is a native of Europe, western Asia, and northern Africa, where it is common but never very seriously injurious.

* *Empusa sphæroperma* Fres.

* *Phytonomus murinus* Fab. Family *Curculionidæ*. See E. G. Titus, Bulletin 110, Utah Agr. Exp. Sta., and F. M. Webster, Circular 137, Bureau of Entomology, U. S. Dept. Agr.

It was first noticed in America near Salt Lake City, Utah, in 1904, and has been increasing and spreading until it now occupies an area of fully 100 square miles around Salt Lake City.

The beetles are from one-eighth to three-sixteenth inch long, dark brown, marked with black and gray hairs which gives them a mottled appearance as shown in Fig. 149*c*. These hairs or scales are gradually rubbed off, so that in spring many individuals are entirely black with small grayish spots.

Fig. 148.—The alfalfa weevil, adults, clustering on and attacking sprig of alfalfa natural size. (After Webster, U. S. Dept. Agr.)

Life History.—The beetles seek shelter for hibernation before frost in the autumn, either in the crowns of the alfalfa plants, or under thick grass, weeds, rubbish, leaves, or in hay or straw stacks. Often they winter in barns where the hay is stored, the floors of which are often found covered with the beetles in winter and spring. It is estimated that fully 80 per cent of the weevils survive the winter in Utah. In the spring the beetles emerge and attack the young alfalfa plants as soon as there is sufficient food for them, usually late in March. The females commence laying eggs in early April and continue oviposition until early July. In early spring while the plants are small the females often push their eggs down between the leaves, but the usual method is to insert them in punctures made in the stem. This puncturing of the young stems often results in considerable damage in early spring. A single alfalfa plant which had escaped from cultiva-

tion was found to contain 127 of these punctures, and as each puncture contains ten or fifteen eggs, this plant probably bore some 1200 eggs, although it was exceptional.

The eggs hatch in about ten days and the small white larvæ make their way to the leaves, in which they eat small holes. They soon turn a decidedly green color, and when full grown are about one-half inch long with a white stripe down the middle of the back and somewhat curved as shown in Fig. 149*c*. They attack the young leaves and crown so that a badly infested field will not get over six inches high; too short to mow. The larvæ are most

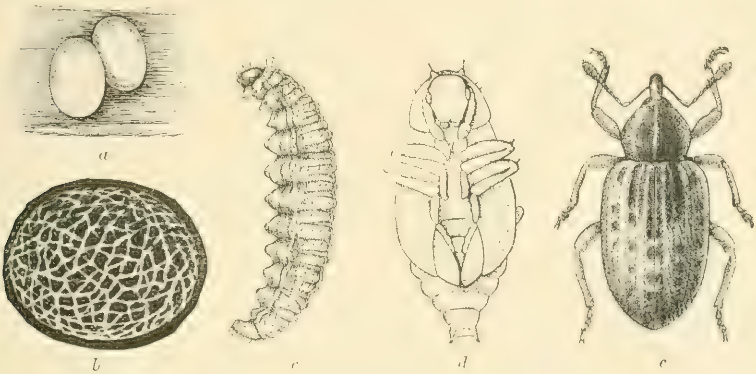


FIG. 149.—The alfalfa-weevil (*Phytonomus murinus*): *a*, eggs; *b*, cocoon; *c*, larva; *d*, pupa; *e*, adult—all much enlarged. (After Webster, U. S. Dept. Agr.)

abundant in May and decrease through June. When full grown the larvæ crawl or drop to the ground and spin their cocoons in the dead leaves or rubbish. The cocoon is globular and composed of a network of rather coarse white threads, Fig. 149*b*. In it the larva transforms to a pupa, which stage lasts from one to two weeks, when the adult beetle emerges.

From early to midsummer the beetles become more and more abundant, and not only feed on the fresh growth, but attack the bark of the stems so that where excessively abundant they totally destroy the second crop.

"The entire life of the insect, from the deposition of the egg to the emergence of the adult, may be anywhere from forty to seventy

days, while the beetle itself may live, including the winter, from ten to fourteen months."—Webster.

Inasmuch as literally millions of the beetles have been gathered by machines from a single acre, and as the beetles have been found in considerable numbers on freight and passenger trains, it is highly probable that the pest will be spread by the several trunk-lines of railroad which pass through the infested region, as in many places alfalfa has escaped from fields and grows as a weed along the railway tracks. It is, therefore, highly important that alfalfa growers be on their guard against this pest and take prompt measures for its destruction wherever it may gain a foothold. The weevils also spread rapidly by flying in spring and summer, which migration is aided by the winds. They may also be spread in articles shipped from an infested region and on wagons or automobiles.

Control. The methods of control have not, as yet, been satisfactorily determined, though the entomologist of the Utah Agricultural Experiment Station, E. G. Titus, has made extensive experiments with various methods, from whose report the following summary is taken.

Old alfalfa fields are always worst injured, and fields should not be left down in alfalfa over about seven years. Thorough disking in the early spring has proved to be one of the essential factors in securing a good crop, as it increases the stand and stimulates a quick growth which enables the plants to better withstand the weevil injury. The use of a brush drag with which a spike-tooth harrow is combined has been found an excellent means of killing the larvae, as they are knocked to the ground and large numbers killed by the fine dust. If the field is very hard it is advisable to disk it before using the drag. After the use of the drag, the fields should be watered where there is irrigation. Several machines have been constructed for gathering the weevils and have proven quite satisfactory. These are being perfected and promise to be of considerable value for the collection of the weevils, particularly when used in conjunction with the brush drags. In summarizing the methods of control, Professor Titus recommends:

"That alfalfa be disked in early spring to stimulate it to better growth. That the first growth be cut when the most of the eggs have been laid (middle of May) and then brush-drag the field thoroughly. Fields should be brush-dragged again after the first crop has been cut. All weeds and rubbish should be cleaned from the fields, yards, ditches and fence rows so that there will be less opportunity for the weevils to find winter shelter. Alfalfa should not be allowed to grow more than seven or eight years in infested districts."

The Clover-mite *

The Clover-mite is nearly related to the common red spider of greenhouses, with which it is often confused, belonging to the same family of vegetable-feeding mites. It is however, about twice the size of the red spider, being fully three-tenths of an inch long.

Though known as the clover-mite, on account of its feeding upon that plant, yet this insect was first known as, and is still, an important enemy of fruit-trees, more especially on the Pacific coast, but also in other sections of the country. The most injury seems to have been done to clover in the Central States as far south as Tennessee, though it has suffered somewhat even in the East.

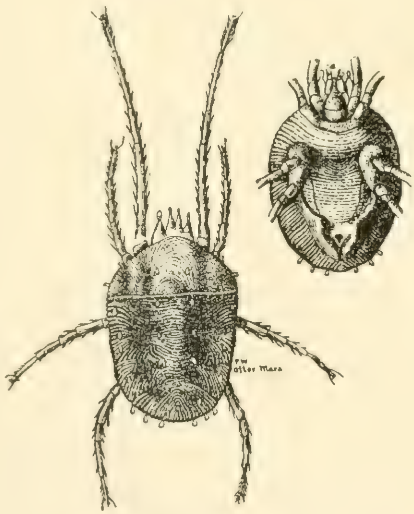


FIG. 150. — The Clover-mite (*Bryobia pratensis*).

When attacked by the mite the leaves of clover or fruit-

* *Bryobia pratensis* Garman. Family *Tetranychidæ*. See C. L. Marlatt, Circular 19, 2d Ser., Division of Entomology, U. S. Dept. Agr.

trees become yellow and have a sickly appearance, as if affected with a fungous disease. Especially upon the upper sides of the tender leaves of clover the juices are extracted over irregular areas, looking more or less like the burrows of some leaf-mining larvæ. Owing to the small size of the mites they may be doing considerable damage to the foliage and yet remain unnoticed; but in the egg stage the pest is much more readily detected and attacked. In the more northern States the eggs are laid in the fall, and do not hatch until the next spring. Further south, however, the adult mites hibernate over winter. The eggs are of a reddish color, laid upon the bark of trees, especially in the crotches, and in the West are sometimes so thickly placed as to cover considerable areas two or three layers deep.

When the adult mites leave the clover-fields in the fall to find hibernating quarters upon fruit-trees for the winter, they often become quite a nuisance by invading dwelling-houses which are in their path. This is more particularly the case throughout the Mississippi Valley.

Remedies.—When swarming into a house their progress may be arrested by spraying the lower part of the building, walls, etc., with pure kerosene as often as necessary. Inside the house they may be destroyed by the use of pyrethrum powder (Persian insect-powder), burning brimstone, or spraying with benzine, care being taken not to bring the latter substance near the fire.

The only practical way of protecting clover from the mite is by destroying the eggs and hibernating mites upon the fruit-trees in winter. This may be done by burning all the prunings and thoroughly spraying the trees with kerosene emulsion diluted with five parts of water, or with miscible oils or lime-sulfur mixture. Such a spraying will also protect the fruit-trees from the mite, and will destroy numerous other insects, such as the pear-leaf blister-mite, which hibernates upon the trees. Such small insects, so minute as to usually escape notice, are often responsible for a poor growth, and should be properly checked whenever known to be injurious.

The Pea-louse *

Although this aphid is worst as a pest of peas (see page 322 for full account) it passes the winter on red and crimson clover which occasionally are seriously injured. In the spring of 1900, both red and crimson clover were badly injured in Delaware, Maryland and Virginia, while in DeKalb County, Illinois, considerable acreages were entirely destroyed in August, 1903, and more or less injury has been done since then. Where peas are available the aphides migrate to them in the spring, but other-

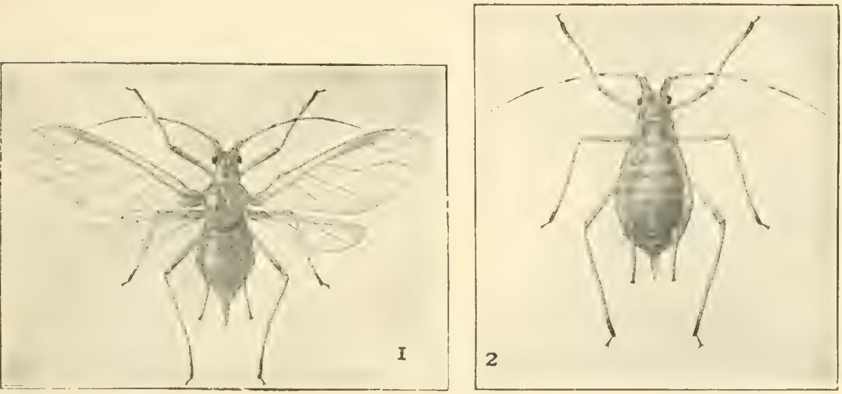


FIG. 151.—The pea-aphis: 1, winged viviparous female; 2, wingless viviparous female—greatly enlarged. (After Folsom.)

wise they continue to multiply on the clover. In late fall they return to the clover upon which the eggs are laid, in which stage the winter is passed, though in open winters many of the viviparous females live over winter on the clover.

Control.—This is another pest which is usually held under control by a fungous disease, and as the fungus does not develop in dry seasons, with dry weather the aphis increases unchecked, while with a normal rainfall it is usually held in subjection, Unfortunately we are unable to predict the weather probabilities, and when the aphides are found present on clover in considerable

* *Macrosiphum pisi* Kalt. Family *Aphididæ.*

numbers, the only thing to do is to cut and cure it as soon as possible, before serious damage has been done. The drying of the clover will kill most of the aphides or cause them to migrate. Spring pasturing or clipping might result in destroying a sufficient number of the aphides so that no serious damage would result later.

The Clover-seed Midge *

The Clover-seed Midge seems to occur wherever red and white clover is grown in this country, and is a pest which must be taken into consideration in raising seed, for frequently it is not recognized as the cause of the failure of the seed crop. Alsike clover, and probably mammoth clover, is practically uninjured, as it flowers enough later to escape attack, nor is alfalfa infested.

Life History.—The parent of all this trouble is a small midge, one-twelfth inch long, with black head and thorax and reddish abdomen, so small, indeed, that it will rarely be noticed. The antennæ have sixteen or seventeen segments, and the wings have but few veins, as shown in Fig. 152. The female bears a slender retractile ovipositor which when extended from the tip of the abdomen is fully as long as the body, while the tip of the abdomen of the male is furnished with clasping organs. The midges appear in late spring just as the clover commences to head. The eggs are laid among the hairy spines of the clover head or beneath the bracts around it, are yellowish to orange in color, of an oval shape, and about $\frac{1}{100}$ inch long. Upon hatching the maggot works its way into the open end of a floret, where it sucks the forming seed, and prevents the petals of the floret from expanding, so that although some of the flowers in the head will bloom, the field as a whole does not blossom as usual. The maggot is footless, white to orange-red in color, and about one-tenth inch long when full grown. Upon becoming grown in late June and the first week of July the maggots enter the soil and just below the surface make tough, oval, silken cocoons, in which they pupate. The pupal stage lasts about

* *Dasyneura leguminicola* Lintner. Family *Cecidomyidæ*.

three weeks or more, and the flies of the second generation appear in Central Illinois in late July and early August, being abundant as the second crop of clover heads appear. The eggs are laid in the clover heads and hatch in about three days, and the second generation of maggots do the worst damage to the seed in late August and early September, in the same manner as did the first generation. They become full grown by frost and hibernate

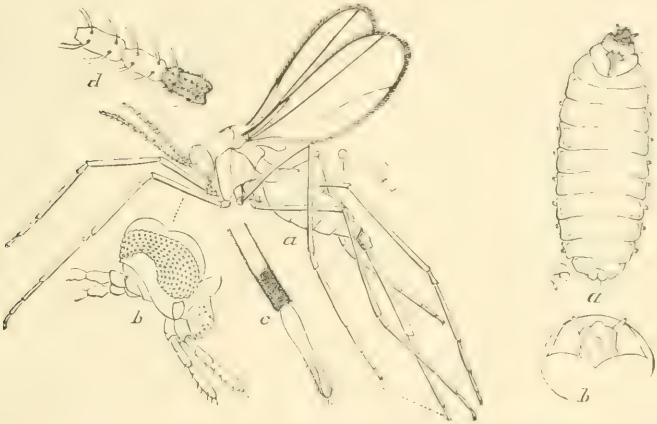


FIG. 152.—The clover-flower midge (*Dasyneura leguminicola*): *a*, enlarged side view of female, with scales denuded, to show more clearly the structure; *b*, head, more highly magnified, to show structure of the eye, palpi, and basal joints of antennæ; *c*, tip of ovipositor, highly magnified and showing at end of next to last joint the manner in which it is clothed with minute hairs; *d*, highly magnified antennal joints, their minute hairy clothing shown on the lower one; 2, *a*, larva enlarged, ventral view; *b*, head retracted, highly magnified. (After Riley.)

either as full-grown larvæ, in which case they pupate early the next spring, or pupate before frost and pass the winter as pupæ in the soil.

Control.—Fortunately this pest may be very readily controlled by adapting the methods of harvesting so as to destroy the developing maggots. If clover is grown alone it should be cut early, before the maggots have become mature. This results in drying up the food plant and thus destroying the larvæ and hastens the development of the second crop of clover heads, so that the midges

of the second generation have but few green heads in which to lay their eggs. Cutting need not be done until the field is fairly fresh with bloom, but should not be delayed until the flowers commence to wither. Where timothy and clover are grown together they should be pastured lightly or clipped back in May, which will result in bringing both the first and second blooming after the greatest abundance of the midges. As the midges do not travel far, it would seem advisable to "prevent the sporadic heading of first-year clover by mowing it back a few weeks after small grains have been harvested, at a time when growth is vigorous, but yet sufficiently early to permit considerable growth before frost sets in. Volunteer clover should always be cut, as it affords a rich nursery for all kinds of clover insects."—Folsom.

The Clover-seed Chalcid *

Evidence accumulates that the shortage of the clover-seed crop may frequently be due to the larva of a little chalcis-fly which hollows out the ripening seed, leaving it brown, brittle and hollow, so that the affected hulls are blown away with the chaff in threshing. As there is no evidence of the pest in the appearance of the heads, and as the worst affected seed are thus overlooked in threshing, its work will often evade detection.

Fig. 153.—The clover-seed chalcis (*Bruchophagus funebris*): adult female, much enlarged; antenna of male at left, more enlarged. (After Webster, U. S. Dept. Agr.)

If the seed crop is short it will be well to examine seed for the larvæ; many of the seed will be found shriveled and misshapen; and frequently considerable numbers of the adults will issue from the seed soon after threshing.

* *Bruchophagus funebris* Howard. Family *Chalcididæ*.

The adult is a small wasp-like fly one-twelfth to one-sixteenth inch long, black in color, and with four wings, the hind wings very small and the fore-wings with but a single vein. It belongs to a family almost all of which are parasitic on other insects, and for many years it was thought to be a parasite of the clover-seed midge, until its true role was discovered. In recent years examinations of ripening heads from all parts of the country show that it is probably distributed wherever clover is grown and that from 20 to 80 per cent of the seed is often destroyed. Both red and crimson clovers are attacked, while alfalfa seed is not so badly injured.

FIG. 154.—The clover-seed chalcis: *a*, egg—highly magnified; *b*, larva and head more enlarged; *c*, pupa—much enlarged. (After Webster, U. S. Dept. Agr.)

Life History.—The winter is passed by the fully grown larvæ in seed on the ground. The adults emerge in the spring, the maximum appearing about June 10th in central Illinois, according to Dr. Folsom, to whom we are indebted for the most careful study of the pest. The females deposit their eggs in the soft seed, just as the floret is withering, being unable to penetrate the seed after it has hardened. The egg is whitish, about $\frac{1}{100}$ inch long, and with a peculiar tail-like appendage (Fig. 154). The maggot-like larva feeds upon the seed, gradually hollowing it out, and when full grown is about one-twelfth inch long, stout and footless, with a small head. The pupal stage is passed within the seed and a second generation of adults emerges about the middle of August.

These lay their eggs in the second growth, and some of the adults from these appear the same season and the rest not until the following year. There seem to be at least three generations a year in central Illinois, but the life history is complicated by the irregularity in the time of development, though the greatest numbers of adults appear about June 10th and August 10th, just as the clover-seed is green.

Control. —No definite experiments have been made in the control of this pest, but from the knowledge of the life history as given above there seems no doubt but that the same measures as are employed against the clover-seed midge will secure immunity from serious injury.

The Clover-seed Caterpillar *

"In its ability to diminish the seed crop, this pest ranks with the seed-midge and the seed-chalcid. Attacking a clover head that is green or partly in bloom, the little caterpillar eats out a

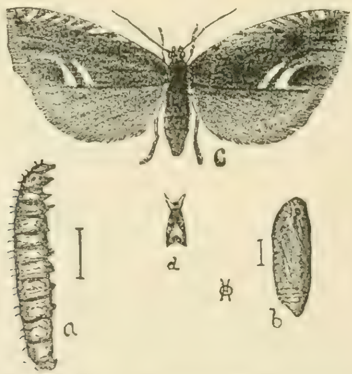


FIG. 155.—Clover-seed caterpillar (*Enarmonia interstinctana*): *a*, caterpillar, *b*, pupa; *c*, moth, all much enlarged: *d*, moth natural size. (After Osborn.)

cavity in the head, destroying many of the unopened buds and some of the tender green seeds, and spoiling the head as a whole. When no young clover heads are at hand, the caterpillar feeds on

* *Enarmonia interstinctana* Clem. Family *Grapholithidæ*.

tender green leaves at the crown of the plant."—Folsom. Red clover is the principal food plant, but white, alsike, and probably mammoth clovers are also affected. The published records show that it occurs in the northeastern States southwest to Missouri, but it doubtless occurs elsewhere where clover is grown, as it might readily be carried in hay.

Life History.—The adult is a pretty little brown moth, with a wing expanse of two-fifths inch, with silvery markings as shown in Fig. 155, the most conspicuous marks forming a double crescent when the wings are closed ou the back. The moths appear about the end of May in central Illinois, or just as the clover is coming into bloom, being active in early evening, when the females lay their eggs in the heads. The egg is circular in shape, about $^1/_{100}$ inch in diameter, yellowish-white in color, and hatches in five or six days. In first-year clover that has not headed and in second-year clover recently cut, the eggs are laid on young stems and leaflets at the base of the plant, where the larvæ stay.

"Hatching usually at the base of a green clover-head; the larva eats into the head, destroying the green florets as it goes. A small green head is often destroyed entirely, before it is many days old; a larger head is injured only locally at first, remaining green on one side, while the other and unaffected side may come into full bloom." Judging from the appearance of the head the work might be that of the seed-midge, but whereas it is hidden away in a single floret, this caterpillar makes a large dirty excavation involving many florets, and is readily found by tearing open the head. The caterpillar attacks the bases of the florets, including the semifluid ovules, but does not attack seeds which have hardened. "Even when the direct injury is confined to a portion of the clover-head, the entire head is ruined, for it at length dries up and loses the rest of the florets, leaving only the dead and brown receptacle. Less conspicuous, though not inconsiderable, is the injury at the crown of the plant, done chiefly in September and October, by caterpillars of the same species feeding upon the leaves."—Folsom. The total injury varies greatly, but not infrequently 20 per cent of the heads are infested, and in Iowa infesta-

tion has sometimes been exceedingly severe. In any event, every head destroyed means the loss of more than one hundred seeds.

The larvæ become full grown in four to five weeks. The full grown caterpillar is about one-third inch long and varies in color from dirty-white tinged with green to orange, according to the food. The larva spins an oval white silken cocoon, two-fifths inch long, either in the head or at the surface of the ground, which is more or less covered with bits of excrement and floral tissue. The pupa is one-fifth inch long, brown, with the thorax and wing-cases darker, and with two transverse rows of teeth on the back of the abdominal segments except the last, which bears six stout blackish hooks at the tip. The pupal stage lasts two to three weeks and a second generation of moths emerges about the third week of July (in central Illinois). The life cycle is repeated in the same manner and a third generation of moths appears about September 1st. The larvæ of the last brood feed either in immature clover-heads or at the crown of the plant. Most of them become full grown and transform to pupæ, in which stage they hibernate over winter, while others become full grown, but fail to pupate and hibernate under rubbish.

Control.—Cutting and storing the hay crop early in June as advised for the clover-seed midge will kill the larvæ while still in the heads. "The hay should be handled lightly and stacked or stored as soon as possible. Osborn and Gossard * have attested the value of this method, and have given these further recommendations: (1) Cut volunteer clover in early June and dispose of the heads speedily; (2) do not allow clover to run for more than two years; (3) sow seed on land remote from old fields; (4) pasture clover in the fall of the first year; (5) plow an old clover-field under in October or November or in early spring, then harrow and roll. These practices operate at the same time against several other clover pests."—Folsom.

* Osborn and Gossard, Insect Life, Vol. IV, p. 254; Bulletins 14 and 15, Iowa Agr. Exp. Sta.; 22d Report Entomological Society of Ontario, p. 74. Gossard, H. A., Bulletin 19, Iowa Agr. Exp. Sta.

The Clover-hay Worm *

The clover-hay worm attacks stacked or stored clover, particularly where it is held over a year or where placed on old hay, eating much of the lower layers and rendering it unfit for food.

FIG. 156.—Clover-hay worm, greatly enlarged. (After Folsom.)

It has been known to be injurious from Kansas eastward, but occurs throughout most of North America, as well as parts of Europe, Asia, and Africa.

FIG. 157.—The clover-hay worm moth, wings expanded (after Folsom) and at rest (after Pettit)—enlarged.

"The larvæ attack the bottom of a clover stack to a height of 2 feet or more from the ground; similarly, in the barn, they occur next the floor. They interweave the hay with white silken webs, intermixed with black grains of excrement. . . ; they

* *Hypsopygia costalis* Fab. Family *Pyralididæ*.

reduce much of the hay to chaff, and their webs give the hay the appearance of being mouldy; in fact, such hay actually becomes mouldy if it has been lying near the ground. This hay is refused by horses and cattle and is fit only to be burnt. When the hay is removed, swarms of wriggling brown caterpillars are left." The work of the caterpillars is usually noticed in late winter and spring.

Life History.—The moths appear from the middle of June until early July in the Northern States and most of the first generation have disappeared by the end of July. The moths have a wing expanse just under an inch, with silky wings, tinged with purplish above, margined with orange and fringed with golden yellow. On each side of the fore-wings are two large, golden spots which divide the anterior margin into thirds and continue backward as narrow lilac lines (Fig. 157). The hind-wings are marked by two transverse, wavy, straw-colored lines.

As soon as some clover-hay is found the female deposits her eggs and the caterpillars feed upon it. When full grown they are about three-quarters inch long, of a dull-brown color. The segments are divided by a transverse groove, and each bears several shining areas, with a fine white hair in each. White silken cocoons, one-half inch long, covered with bits of hay and excrement, are made by the larvæ in the hay or in cracks and crevices of the barn, in which they transform to pupæ, which are of a honey-yellow color, with the parts clearly defined by the darker color of the sutures. The moths of the second brood emerge from the middle of August until September 1st, but may be found flying until late October. Caterpillars of all sizes may be found in barns throughout the winter and pupate in the spring.

Control.—Usually no serious injury is done except where clover-hay is kept over the second year or longer. When it is fed out each spring, before the next crop is harvested, there is no food for the young caterpillars, and they perish before the new crop comes in. Consequently mows should be cleaned out each spring. New clover-hay should never be placed on top of old hay, and stacks should be placed at some little distance

from the old stacks if possible. Burn up the refuse from old stacks, or what remains in the bottom of the mow. Stacks should be raised above the ground on a foundation of logs or rails, so as to keep the bottom as dry and cool as possible, as the caterpillars love warmth and moisture. It has been found that salting the hay for 2 or 3 feet at the bottom will prevent injury, and many farmers salt their clover-hay, using about two quarts of salt to the ton.

CHAPTER XII

INSECTS INJURIOUS TO TOBACCO *

The Tobacco Flea-beetle †

THE Tobacco Flea-beetle is one of the important pests of that plant throughout the Middle States, being particularly injurious to young plants. The beetles damage the leaves by eating small

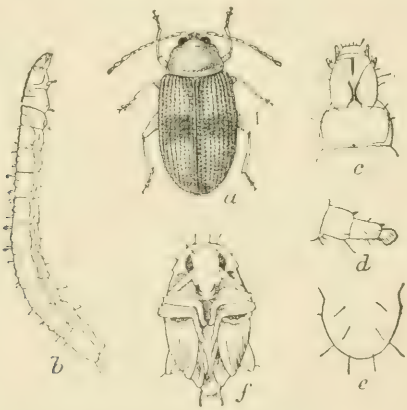


FIG. 158.—Tobacco flea-beetle (*Epitrix parvula*): *a*, adult beetle; *b*, larva, lateral view; *c*, head of larva; *d*, posterior leg of same; *e*, anal segment, dorsal view; *f*, pupa—*a*, *b*, *f*, enlarged about fifteen times; *c*, *d*, *e*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

holes in the upper or under surfaces, or clear through them, so that when badly eaten the leaves look as if they had been peppered with shot. The little beetles which do this damage are hardly

* See L. O. Howard, Farmers' Bulletin 120, U. S. Dept. Agr., The Principal Insects Affecting the Tobacco Plant. A. C. Morgan, Circular 123, Bureau of Entomology, U. S. Dept. Agr; Yearbook, U. S. Dept. Agr., 1910, pp. 281–296.

† *Epitrix parvula* Fab. Family *Chrysomelidæ*.

more than one-twentieth inch long, light brown in color, with a dark band across the wing-covers. A few of them could do but little damage, but they soon increase in numbers, so that they swarm over the leaves and injure them badly. Similar injury is done to potato, egg-plant, and tomato, and the beetles also feed on horse-nettle, nightshade, and Jamestown weed.

Life History.—The eggs are laid in the soil and the larvæ feed upon the roots of common weeds, such as the nightshade and Jamestown weed. The larva is delicate, thread-like and white, except the yellowish head, and about one-eighth inch long. It pupates in the soil. When the beetles become very numerous the larvæ sometimes develop on the roots of tobacco, but rarely do serious damage. The life history has not been determined exactly, but the full life cycle seems to occupy about a month, so that there are probably several generations in a year.

Fig. 159.—Tobacco leaves damaged by *Epitrix parvula*. (After Howard, U. S. Dept. Agr.)

Control.—Inasmuch as the larvæ develop on the roots of the weeds mentioned, it is evident that they should be kept down by thorough cultivation. Where the beetles appear, the plants should be sprayed or dusted with Paris green, or probably better, arsenate of lead, the same as for the horn-worm. Dipping the plants in arse-

nate of lead, 1 pound to 10 gallons of water, just as they are set, has been found to afford very satisfactory protection in Connecticut.

The Tobacco Stalk-worm *

Professor W. G. Johnson found this species, also known as the Corn-root Webworm, to be a serious pest to growing tobacco-plants in southern Maryland, where it seems to have been a tobacco pest for at least fifteen years, and it has also been noted in Delaware.

The Injury.—The injury to tobacco is described by Professor Johnson as follows: "The uninjured tobacco had a leaf-spread of from ten to twelve inches. A few rods beyond, where the soil was not so gravelly and better, we found the larvæ had literally destroyed the first and second plantings, and were at work upon the third, damaging it severely, although the ground had been replanted before the last planting. Here and there was a young plant just beginning to wilt, and invariably we found the larva at work either in the stalk or at the base of the plant just below the surface of the ground. So far as I could ascertain the attack is always at the surface or just below. In many instances the larvæ had hollowed out the stalks from the base of the roots to the branches of the first leaves. Many plants were gnawed irregularly around the stalk below the surface, and some, in fact, were completely cut off at the surface, the insect always working from below. In the great majority of cases the larvæ were found in a small mass of web near the plant, and sometimes within it. In one plant, less than six inches high, we found four larvæ within the stalk, but as a rule only a single one was present."

Professor Johnson concluded "(1) that it is most likely to occur over local areas in tobacco following timothy or grass; (2) that the character of the soil has little or nothing to do with its ravages; (3) that the attack upon corn is also a frequent occurrence in the same section; especially when following grass or timothy."

* *Crambus caliginosellus* Clem. Family *Crambidæ*. See p. 161 and Bull. 20, n. s., Div. Ent., U. S. Dept. Agr., pp. 99–101, 1899.

Remedies.—He recommended " (1) that growers of tobacco avoid planting upon grass or timothy sod; (2) that where grass land is plowed down it would be well to put it in wheat, following with clover, before tobacco. If desirable, corn could follow the grass and the land could be seeded in crimson clover at the last working. This would serve a twofold object by revealing the exact location of larvæ in the area under cultivation by their attack upon corn, when they could be destroyed largely by frequent harrowing and rolling, and by affording a most excellent soil crop to turn down the following spring, which would be a decided advantage to the tobacco; that if it is found necessary to have tobacco following grass, it should be broken in the spring as early as possible, and frequently rolled and harrowed, at the same time delaying the setting of the plants as long as possible in order to destroy and starve the larvæ within the ground."

The Spined Tobacco-bug *

Professor H. Garman has found a small bug, which he has termed the Spined Tobacco-bug, doing more or less injury to plants

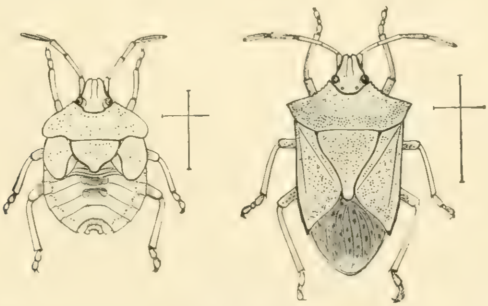


FIG. 160.—The spined tobacco-bug (*Euschistus variolarius*), nymph at left; adult at right—enlarged. (After Howard, U. S. Dept. Agr.)

in Kentucky, and as this insect is widely distributed throughout the country, it probably does more or less damage elsewhere, though never a serious pest. Concerning its work, he says: " Occa-

* *Euschistus punctipes* Say (*variolarius* Pal. Beauv.). Family *Pentatomidæ*. See Bulletin No. 66, Ky. Agr. Exp. Sta., p. 33.

sional plants in tobacco-fields are at times observed to have become suddenly wilted, the leaves hanging limp, much as if the stalk had been severed. After a time they recover again, and, beyond a temporary check on their growth, appear to have suffered but little injury. If such plants are searched carefully while still wilted, a flat, brown bug with each side of the body produced into an angle, or sharp spine, will be found upon the stalk along the base of the leaves. It is very shy and keeps out of sight, hence any brisk movement on the injured plants is likely to cause it to drop to the ground and conceal itself." These insects are true bugs, sucking their food through a beak, which is bent under the body between the legs when not in use. They are about half an inch long, of a drab color above and greenish or yellowish below. Usually only one bug is found on a plant, so that the best way to prevent the injury is to pick them from the plants, and keep down such weeds as thistles and mulleins, upon which such insects feed, in the adjoining fields.

The Suck-fly *

One of the worst tobacco pests in many parts of Florida is a little bug called by the planters the "suck-fly," which fortunately does not seem to have become a pest elsewhere. They insert their little beaks into the tissue of the leaf and suck the juices, causing the leaf to become yellowish and wilted, and cracking older leaves so that they become ragged. As a result it is exceedingly difficult, if not impossible, to properly cure badly infested leaves.

Life History. The adult is a small bug about one-eighth inch long, with rather long yellowish-green legs. The upper surface is black, except the front margin and a central stripe of yellow on the pro-thorax, while the under side is greenish. The "flies" become numerous enough to be injurious early in June, usually being noticed first in one corner of a field near where they have hibernated. They rarely do serious damage to the first crop, but the second crop and late tobacco is sometimes entirely destroyed. They have also been noted in the Gulf States as injuring tomatoes.

* *Dicyphus minimus* Uhler. Family *Capsidæ*.

The eggs are deposited singly in the tissues of the leaf and hatch in about four days. The young nymphs feed on the foliage, as do the adults, and after moulting four times transform to adults about eleven days later. Thus it requires but about a fortnight for the

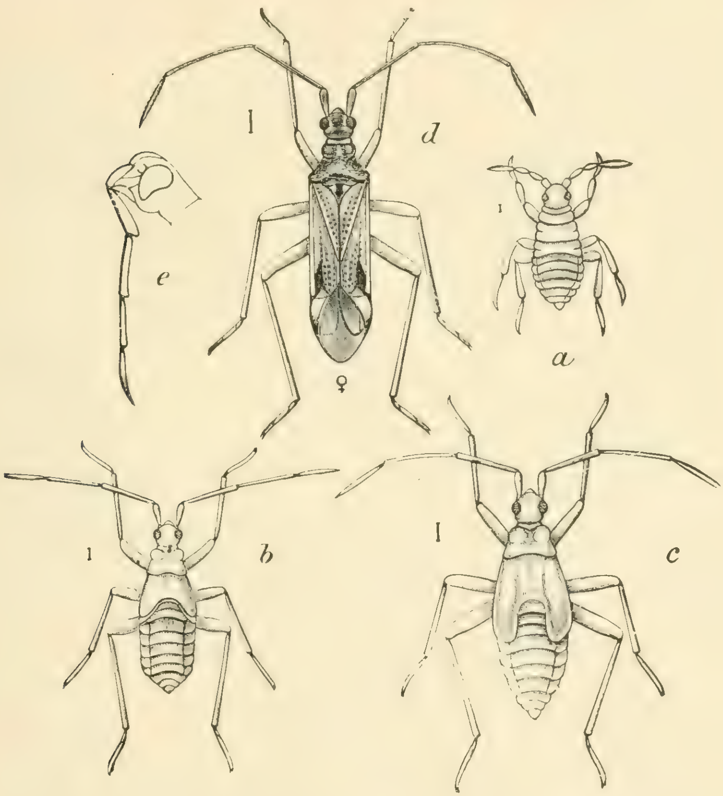


Fig. 161.—The suck-fly (*Dicyphus minimus*): *a*, newly hatched; *b*, second stage; *c*, nymph; *d*, adult; *e*, head and beak from side—enlarged. (After Howard, U. S. Dept. Agr.)

development of a brood, so that the pest multiplies very rapidly and in a few weeks becomes so numerous that hundreds are found on a single leaf and serious injury is inevitable.

The weather plays an important part in the control of this pest, as many of the insects become stuck to the sticky exudation

given off by the glandular hairs of the tobacco, and if there be frequent rains, this is washed off and the insects develop unimpeded. The bugs are found in late fall until frost, but the exact number of generations has not been determined. They evidently hibernate in or near the tobacco field.

Control.—Professor A. L. Quaintance, who experimented with remedies in Florida, has found, curiously enough, that the best insecticide against this pest is its own food, tobacco. A solution of concentrated nicotine, diluted with sixty parts of water, was found very effective when sprayed upon the bugs. It should be applied with a bent-necked nozzle which will throw a fine spray upon both surfaces of the leaves, as most of the young are on the lower surface. Home made tobacco decoction (page 55) was also used, but did not prove as satisfactory. The spraying should be done early in the day, when the adult bugs are sluggish and do not fly readily. Infested areas should be sprayed when the pest first makes its appearance so as to prevent multiplication and spread. Thorough cleaning up of rubbish and destruction of the old stalks in the fall will be of service against this as well as other tobacco pests. A few plants set early in the spring would probably attract the hibernating bugs as they emerge, so that they might be readily killed upon them.

The Hornworms or Tobacco-worms *

Of all the insects feeding upon tobacco, the Hornworms are the most widely injurious and therefore best known. The caterpillars of two species of moths are commonly included under this popular name, both species occurring throughout the tobacco-growing States, the northern tobacco-worm being more common in the North and the southern tobacco worm more common in the South. The differences in the adult moths may be readily appreciated from Figs. 162 and 163, the southern form being darker and with brighter orange spots on the abdomen, and the white lines on

* *Phlegethontius quinquemaculata* Haworth (Northern), and *P. sexta* Johanssen (Southern). Family *Sphingidæ*.

the hind-wings being less distinct. The larvæ of both species commonly attack tomato vines and are commonly called tomato worms where tobacco is not grown.

Life History.—The pupæ pass the winter several inches below the surface of the soil and from them the moths emerge in May and

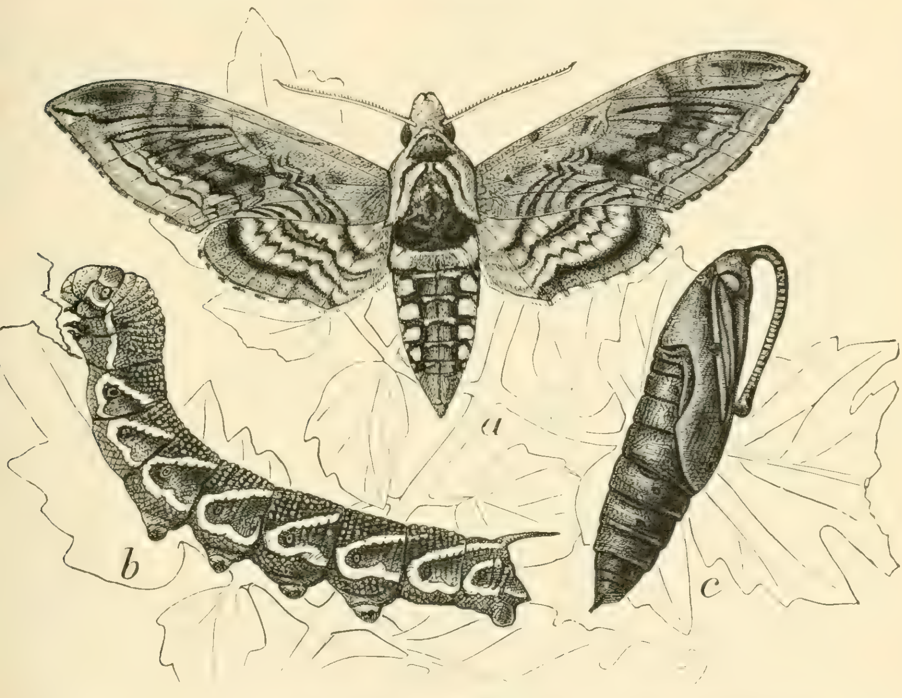


FIG. 162.—Northern tobacco-worm, or "hornworm" (*Phlegethontius quinquemaculata*): *a*, adult moth; *b*, full-grown larva; *c*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

June, according to the latitude and season. The females deposit their eggs singly, upon the lower surfaces of the leaves, from which the little caterpillars hatch in from four to eight days. The characteristic work of the larvæ is too well known to every tobacco grower to necessitate description. The caterpillars become full grown in about three weeks, during which time they moult some five times. The full grown larvæ are three to four inches long, of

a dark green color with white stripes on the side of the body, those of the northern species having a V-shape, while those of the southern species being simple oblique bands. At the tip of the abdomen is a stout horn, from which is derived the name of hornworm, which in the northern species is black and in the southern is red. The pupæ are formed in the soil, are dark brown, about two inches

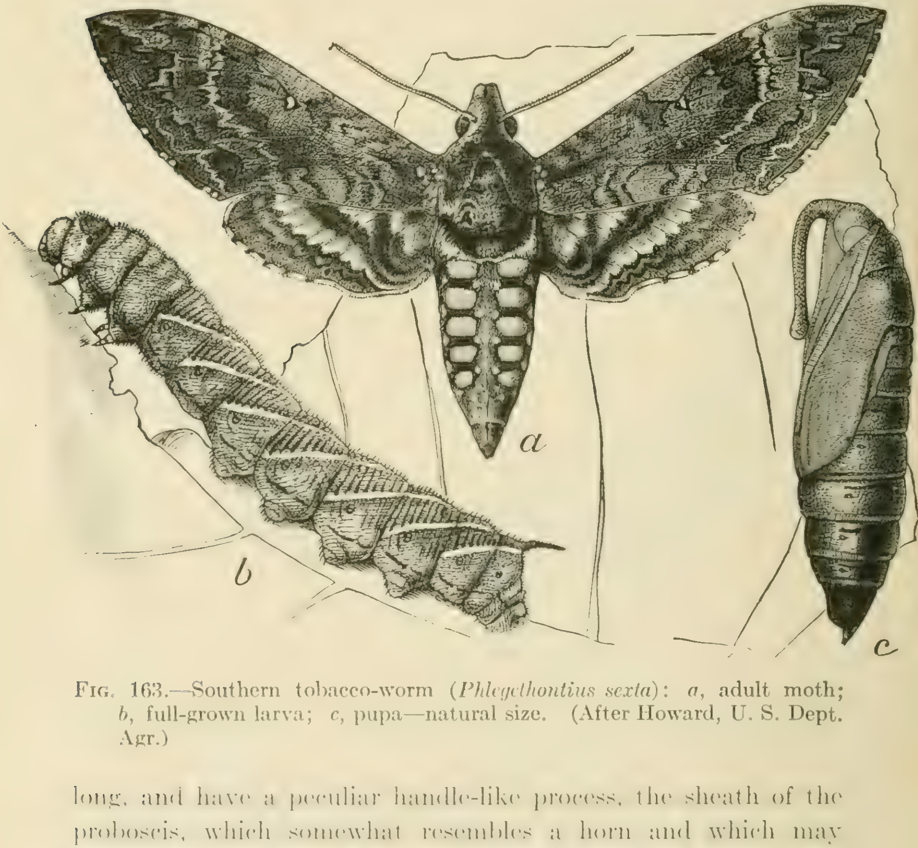


FIG. 163.—Southern tobacco-worm (*Phlegethontius sexta*): *a*, adult moth; *b*, full-grown larva; *c*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

long, and have a peculiar handle-like process, the sheath of the proboscis, which somewhat resembles a horn and which may account for the name of "hornblowers," commonly given them in Maryland and Virginia. The pupal stage lasts about three weeks, when the adults emerge, the whole life cycle requiring from six to eight weeks. Usually two generations occur in a season throughout most of the tobacco belt, but in the North there seems to be

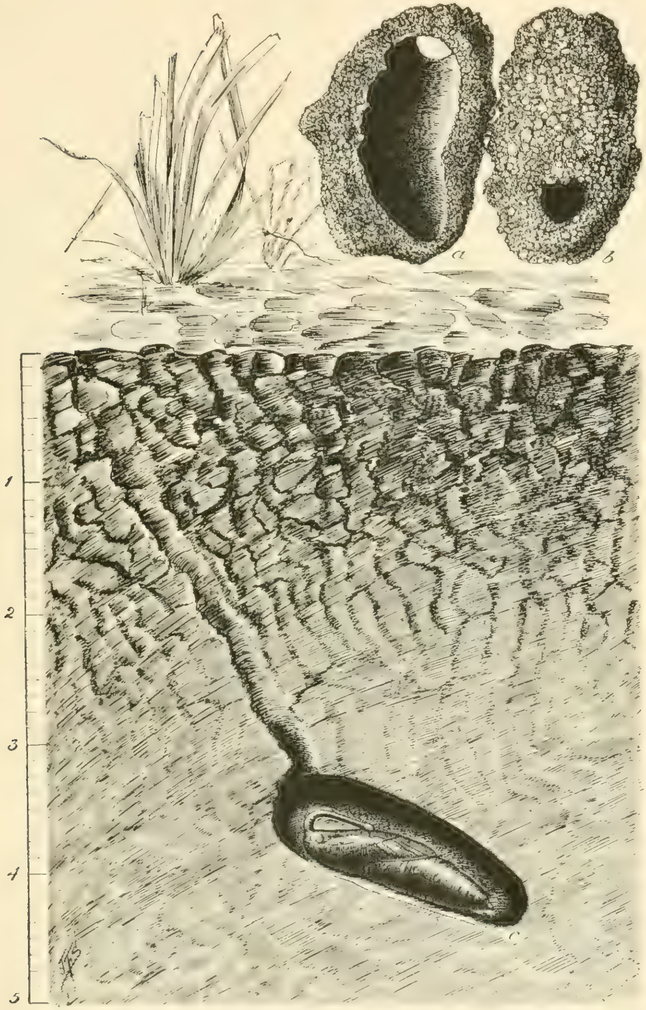


FIG. 164.—Hibernation of southern tobacco-worm; *c*, pupa in hibernating cell in soil, at the depth of which pupation usually takes place in the stiffer soils; *a*, cross-section of pupal cell viewed from below; *b*, pupal cell showing entrance hole of larva—two-third natural size. (After A. C. Morgan, U. S. Dept. Agr.)

but one generation, and in the Gulf States there may be three generations. Occasionally the worms are overlooked in cutting the tobacco and are carried into the barn, where they may do considerable injury even after the tobacco is partially dry.

Control.—The most common method of control is hand-picking, usually termed "worming." In seasons when the worms are not overabundant this may be the most practical method of control, but it is both tiresome and expensive, and the planter has no means of predicting whether the worms will be more or less abun-

FIG. 165.—Southern tobacco-worm killed by fungus. (After Garman.)

dant. Large flocks of turkeys driven through the fields will aid most efficiently in this work.

In many sections the worms are now controlled by spraying or dusting with Paris green or arsenate of lead. More or less popular prejudice against the use of arsenicals has existed, as it was thought the tobacco might be poisonous to the consumer. Careful chemical examinations have shown, however, that the amount left on the foliage after three sprayings would be far too small to have any deleterious effect. The same prejudice formerly existed against the use of arsenicals on potatoes, cabbage and other crops, but experience has shown it to be unwarranted. A real objection to the use of Paris green is that it sometimes slightly burns the foliage, so that arsenate of lead will doubtless be found preferable.

By spraying three times, the worms may usually be entirely controlled at much less expense than by hand-picking. The time of the spraying will depend upon the latitude and season, but it should be applied as soon as each brood of young caterpillars appears. Usually one spraying should be given about July 1st, a second early in August, and another in about two weeks to check the work of the second brood, which is the most injurious. One pound of Paris green to 160 gallons of water is sufficient, and it should never be used stronger than 1 pound to 125 gallons. Arsenate of lead may be used at the rate of 2 or 3 pounds to 50 gallons or dusted on as a powder. These treatments will also aid in controlling the bud worms.

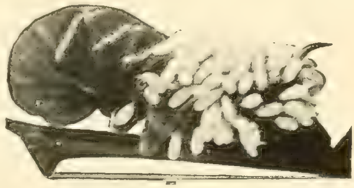


Fig. 166.—Southern tobacco-worm with cocoons of parasite. (After Garman.)

A method of killing the adult moths has been practiced by many planters with satisfactory results. It consists of poisoning the flowers of the Jamestown weed (*Datura stramonium*) with a sweetened cobalt solution. The flowers are placed around the fields in the evening, being set upright in holes in horizontal slats, or supported by sticks. The cobalt solution is then introduced into them by means of a quill, or dropper. It is composed of: cobalt, 1 ounce; molasses, one-fourth pint; and water, 1 pint. In their search for flowers the moths will be attracted by the odor of molasses and the cobalt of the solution will poison them, and thus prevent the female from laying some 200 eggs toward another brood of worms.

As the pupæ hibernate in the soil it is evident that deep plowing and thorough harrowing in late fall and winter of land which has been in tobacco will result in destroying many of them. The destruction of the stalks and cleaning up of refuse leaves after the crop has been removed is also of importance, as the larvæ may continue to feed in the field and become full grown and pupate where by the destruction of their food this might be prevented.

Natural Enemies.—Very frequently worms are found covered with what seem to be small, white eggs. These are not eggs, however, but are the small silken cocoons of a little wasp-like parasite (*Apanteles congregatus*) whose larvæ feed internally upon the juices of the worm and thus ultimately kill it before it transforms to a pupa. Such parasitized worms should never be destroyed, as the parasites are of more value than the damage the worm might do. Very frequently the caterpillars are attacked by a bacterial disease which causes them to turn dark and become shrunken and flaccid.

The Budworms *

Two caterpillars of the same genus commonly attack the bud of tobacco and have been distinguished by Dr. L. O. Howard as the true budworm and false budworm, the latter being the same as the well-known cotton bollworm and corn ear-worm.

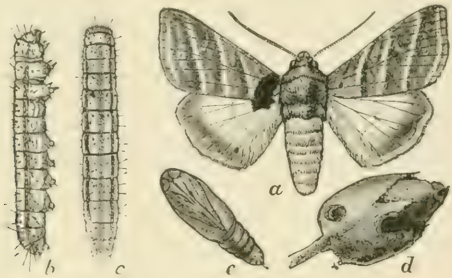


FIG. 167.—The true budworm (*Chloridea virescens*): *a*, adult moth; *b*, full-grown larva, from side; *c*, same, from above; *d*, seed-pod bored into by larva; *e*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

"The true budworm (*Chloridea virescens*) occurs in the more southern portions of the tobacco-growing regions," says Dr. Howard, † "but has not been noted in tobacco-fields north of Maryland. The adult insect is a small greenish moth, well illustrated in Fig. 167. The larva or caterpillar of this moth, also illustrated, is

* *Chloridea virescens* Fab., and *Heliothis obsoleta* Fab. Family *Noctuidæ*.
† Farmers' Bulletin 120, U. S. Dept. Agr. The Principal Insects Affecting the Tobacco Plant.

nearly always found in the bud of the tobacco-plant about the time the plant is ready to top. In some seasons they occur in large numbers and damage the tobacco considerably. In the early part of the season, as a general thing, but few of them are found, and in ordinary seasons they are not especially noticed during the early "worming" of the tobacco. In August they begin to be more abundant, and generally leave the plant about the end of the month, entering the ground, transforming to pupæ and issuing as moths toward the end of September. These dates are for Virginia, but hold reasonably well as far south as Mississippi. The greatest damage done by this insect is by the August brood, when it enters the rolled-up leaves or bud of the plant. In September and October the next generation of caterpillars is found boring into the seed-pod and occasionally into the flower-stem. . . . The caterpillars of the last fall generation enter the ground and hibernate as pupæ. The insect has several other food-plants aside from cotton, but its most abundant food in the South is the weed known as ground cherry (*Physalis viscosa*)." The life history of this species is very similar, therefore, to the false budworm or bollworm.

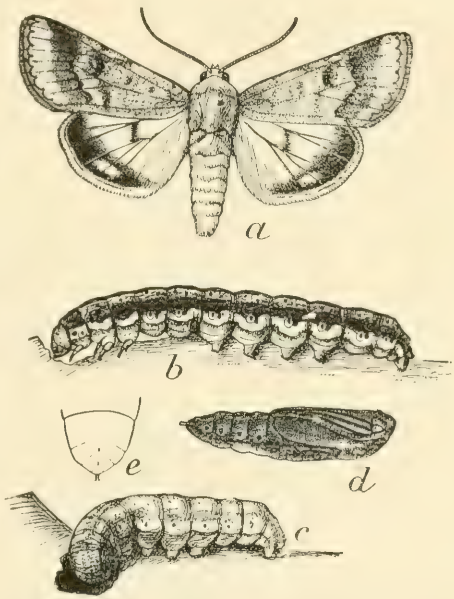


Fig. 168.—Flase budworm or cotton bollworm (*Heliothis obsoleta*): *a*, adult moth; *b*, dark full-grown larva; *c*, light-colored full-grown larva; *d*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

The corn ear-worm (see page 181) is usually found attacking

tobacco in Virginia and Kentucky only late in the season after corn has commenced to harden. It then bores into the buds, seed-pods, and flower-stalks, in the same manner as the last species. In Florida, however, Professor A. L. Quaintance states that its worst injury is done early in the season before corn or cotton are available, the eggs being laid in the bud and the young larvæ feeding on the

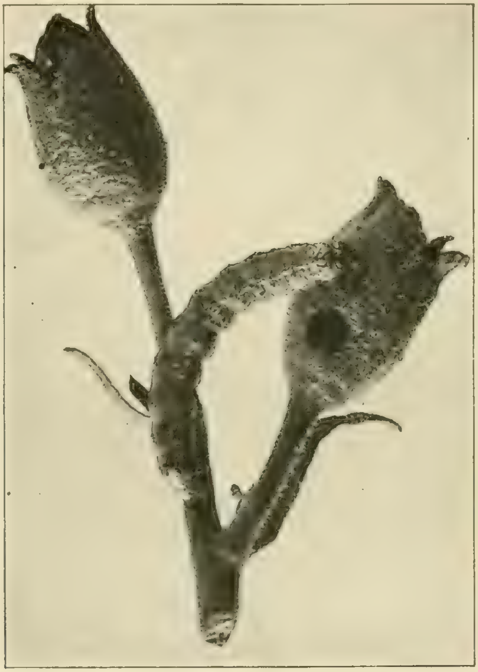


Fig. 169.—Larva of false budworm (*Heliothis obsoleta*), showing work on seed-capsules of tobacco plant. (After Quaintance.)

unfolded leaves, doing very serious injury. In Florida the corn ear-worm or false budworm is more common than the former species.

Control.—Poisoned corn-meal has been found to be a satisfactory remedy for both species when they bore into the bud. Mix a half teaspoonful of Paris green into a quart of finely ground corn-meal and sprinkle into the buds from a can perforated like a pepper

can. This should be applied frequently, especially after heavy rains. Large buds should be opened and a pinch of the poison placed within. When spraying or dusting with an arsenical is practiced against the hornworms it will aid in the control of the budworms, and may be advisable for them alone where injury is serious. Powdered arsenate of lead has been used against both these insects with considerable success and will doubtless obviate the burning which has been experienced when using Paris green with corn-meal. When the injury by the false budworm occurs only late in the season, it would seem that the moths might be attracted to a trap crop of late corn in the same manner as cotton is protected from it (page 257).

The Tobacco Leaf-miner *

The larva of a small moth has become quite injurious in parts of North Carolina and Florida by mining the inside of the leaf,

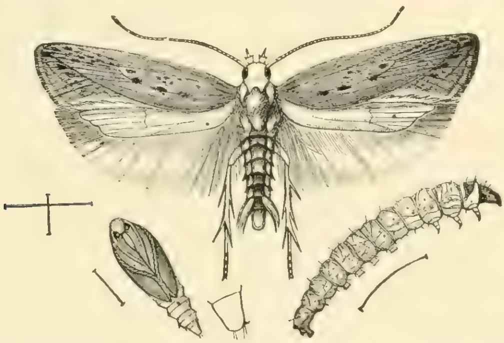


FIG. 170.—Tobacco leaf-miner or split-worm, adult moth above; larva below at right; pupa below at left, with side view of enlarge l anal segment—all enlarged. (After Howard, U. S. Dept. Agr.)

and is thus known as the Tobacco Leaf-miner. This insect occurs in other parts of the country, but has become injurious only in the States named and in recent years. The injury is done by the

* *Phthorimæ operculella* Zell. Family *Tineidæ*.

larvæ eating out irregular patches of the tissue in the leaves, leaving only the upper and lower surfaces, the lower leaves being infested the worst. The leaves are rendered unfit for wrappers, splitt ng and tearing very easily on account of these blotches. A larva does not confine its work to one place, but makes several mines, and a single larva may thus destroy the value of a leaf for wrapping purposes. This migratory habit is of considerable importance, as in leaving the old and in making new mines the larvæ must necessarily eat a certain amount of the surface of the leaf, and can thus be killed by an arsenical spray. The life history of the insect is not completely known, but as only about twenty days are required for all its transformations, several broods probably occur during a season. The original food-plant of this pest has been found to be the common horse- or bull-nettle (*Solanum carolinense*), which fact further emphasizes the caution already given, to keep all weeds carefully cut down around the tobacco-field, especially those nearly related to tobacco botanically. Many planters destroy the larvæ by simply crushing them with the hand, and this can be done quite rapidly, and if done before the mines become numerous should be sufficient to check the injury. Where spraying with Paris green is practised against the hornworm it should be sufficient to destroy most of the miners, as, if the leaf is thoroughly coated with poison, they would get a fatal dose in starting a new mine.

Fig. 171.—Work of split-worm — reduced. (After Howard, U. S. Dept. Agr.)

The Cigarette-beetle *

The most serious pest of dried tobacco is the little brown Cigarette-beetle, which also attacks various drugs and stored food products. The beetle is but one-sixteenth inch long, of a brownish color, and with the pro-thorax bent down so that the head is obscured as if under a hood.

"Working as it does in all kinds of cured tobacco and living in this substance during all the stages of its existence," says Dr. L. O. Howard, "it damages cigarettes and cigars principally by boring out of them, making round holes in the wrappers so that they will not draw. Leaf tobacco is injured for wrapping

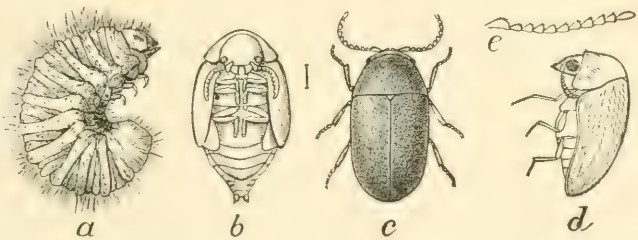


FIG. 172.—The cigarette-beetle: *a*, larva; *b*, pupa; *c*, adult; *d*, side view of adult; *e*, antenna—all greatly enlarged; *e*, still more enlarged. (After Chittenden, U. S. Dept. Agr.)

purposes by being punctured with holes made both by the larvæ and beetles, and fillers and finecut are injured by the reduction of their substance by the actual amount consumed by the larvæ." "The cigarette-beetle is practically cosmopolitan, and probably occurs in most tobacco factories in the Southern States, as well as in most wholesale drug stores. In the far South this insect multiplies rapidly throughout the greater part of the year, and its development is practically continuous in artificially warmed factories farther north."

Life History.—In heated factories the insect may be found in all stages throughout the year. Otherwise it seems to pass the winter months in the larval state. The larva is slightly larger

* *Lasioderma serricorne* Fab. Family *Ptinidæ*.

than the beetle and covered with hair as shown in Fig. 172. When full grown it spins a compact silky cocoon covered with bits of whatever it is breeding in and in it transforms to the pupa. In a warm room the entire life cycle has been passed in forty-seven days, and it seems probable that in the District of Columbia, there are two generations a year. The life is undoubtedly intimately related to the moisture and temperature conditions under which it lives.

Control.—When a factory or storehouse has become badly infested a thorough cleaning is the first step in the control of the pest, as tobacco fragments and dust are usually present everywhere and ideal conditions for the multiplication of the pest are afforded.

Infested tobacco should be opened up, if packed tightly, placed in tight boxes or in a tight room and exposed to the fumes of carbon bisulfide, using it the same as for grain insects (see page 57). The quantity used will depend upon the tightness of the enclosure, the way in which the tobacco is packed, and the temperature. One pound to every 200 cubic feet will usually be ample. In factories where the beetle is abundant the tobacco should be steamed before use, which will kill all stages of the insect. Loose tobacco, cigars, and cigarettes, should not be left exposed to the beetles, but should be covered up or placed in tight receptacles to prevent their access. Badly infested factories and storehouses may be fumigated with hydrocyanic acid gas (see page 57).

Several other insects are more or less serious pests of tobacco in certain parts of the country or under local conditions. The Tobacco Thrips * has caused considerable loss to growers of wrapper tobacco in Florida where it is grown under shade.

* *Euthrips nicotianæ* Hinds. Order *Thysanoptera*. See W. A. Hooker, Bulletin 65, Circular 68, Bureau of Entomology, U. S. Dept. Agr.

CHAPTER XIII

INSECTS INJURIOUS TO COTTON *

Plant-lice †

WITH the formation of the first true leaves of cotton, winged aphides or plant-lice appear in large numbers on the under side and on the terminals, the "buds" of the plants often being black with them. Almost all of them are the common greenish Melonaphis ‡ (see page 383), which infests melons later in the season. It is evident, therefore, that the practice of planting cotton between rows of melons is undesirable. The aphides migrate to the cotton while it is young from various common weeds upon which they have passed the winter.

Another species, known as the Bur-clover Aphis § occurs on cotton at about the same time and is not readily distinguishable from the previous species, but is darker and has a shining reddish or brownish-black color.

In cold weather these plant-lice often cause considerable injury to the young plants, and greatly retard their development, since they multiply very rapidly and feed mostly on the growing terminals. If there be a few warm days, however, hordes of small hymenopterous parasites appear and in a few days often completely rid the plants of the pest.

Control.—Although these aphides may be destroyed by spraying with kerosene emulsion, whale-oil soap, or tobacco water,

* See Hunter and Hinds, The Mexican Cotton Boll Weevil, Bulletin 51, Bureau of Entomology, U. S. Dept. Agr.; Quaintance and Brues, The Cotton Bollworm, Bulletin 50, Bureau of Entomology, U. S. Dept. Agr.; Sanderson, Miscellaneous Cotton Insects of Texas, Bulletin 57, Bureau of Entomology, Farmers' Bulletin 223, U. S. Dept. Agr.

† Family *Aphididæ*. ‡ *Aphis gossypii* Glov.

§ *Aphis medicaginis* Koch.

Fig. 173.—The cotton worm (*Alabama argillacea*): young and full-grown larvæ or worms, pupa, cocoons in folded leaves, and moths, at rest, and with wings expanded—three-fourths natural size. (After Comstock.)

yet as a rule their use on any considerable scale will hardly be profitable. Keeping the fields clear of weeds by fall and winter plowing will undoubtedly have a beneficial effect in reducing the numbers of aphides and in most cases will be the only treatment necessary.

The Cotton Worm *

Until the advent of the boll weevil, the cotton worm was much the most serious insect pest of cotton. Since then, however, its importance has been rather overshadowed in the mind of the

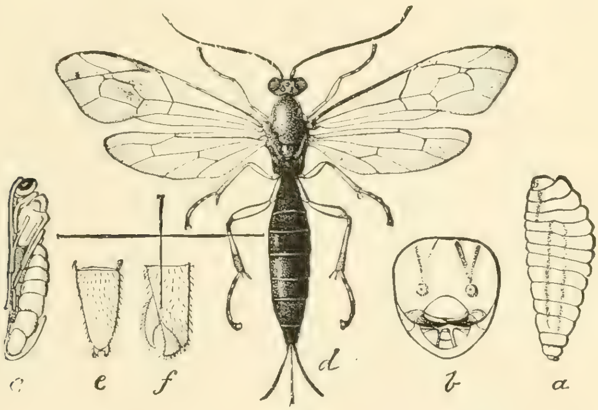


FIG. 174.—*Pimpla conquisitor*, one of the principal parasites of the cotton-caterpillar: *a*, larvæ enlarged; *b*, head of same still more enlarged; *c*, pupa; *d*, adult female enlarged; *e*, *f*, end of abdomen of adult male, still more enlarged. (From Fourth Rept. U. S. Entom. Comm.)

planter by the onslaught of the invading Mexican pest and where the boll weevil is abundant the stripping of the late foliage by the cotton worm really aids in the control of the weevil, as will be explained later.

Life History.—During the winter months the adult moth hibernates in the most southern portion of the cotton-belt, in the rank wire-grass occurring in the more thickly timbered regions. Only a few of these survive, but they are very capable ancestors. In early March they lay eggs upon volunteer cotton when it is

* *Alabama argillacea* Hubn. Family *Noctuidæ*.

only an inch or two high. The eggs are laid singly, usually upon the under surface of the leaves near the top of the plant, and about 500 are laid by each female. The egg is of a flattened convex shape, bluish-green in color, and with prominent ridges converging to the apex. In midsummer the eggs hatch in three or four days, but in spring and autumn a much longer time is required. The young larvæ are a pale yellow color, but soon assume a greenish tinge, and are marked with dark spots which become more distinct after the first moult, when they become marked like the full-

Fig. 175.—Cotton-worm egg parasite (*Trichogramma pretiosa*): *a*, adult female, greatly enlarged; *b*, ovipositor; *c*, female antenna; *d*, male antenna. (From Fourth Rept. U. S. Entom. Comm.)

grown caterpillars, being more or less striped with black. During the early season the greenish caterpillars predominate, but later the black stripes become heavier and the darker forms prevail. The appetites of these caterpillars are only too well known to the cotton-grower. At first they are content with eating only the under surfaces of the leaves, occasionally piercing through. Then the leaves commence to look ragged, and when they become scarce the tender twigs and buds are attacked. When they are excessively abundant the larvæ develop cannabalistic tendencies, like the boll worms, and often feed upon the weaker caterpillars.

The larvæ become full grown in from one to three weeks, during which time they moult some five times.

When mature the caterpillar crawls into a folded leaf, which is often so eaten away that the pupa hangs exposed, and there spins around it a thin silken cocoon and transforms to the pupa, in which state the insect remains dormant for from one to four weeks, when it emerges as an adult moth.

The moth is a dull olive-gray color with a wing expanse of about $1\frac{1}{3}$ inches, which sometimes have a purplish lustre, and which are marked with darker lines as shown in Fig. 173. Like most of the owlet moths it flies only after sunset, but unlike them, it is not confined to the nectar of flowers for food, as its mouth is peculiarly adapted to piercing the skin of ripe fruit and feeding upon its juices. The moths are strong fliers, those of the later broods being frequently found as far north as Canada.

The first two generations develop rapidly and in the extreme South the moths emerge by early April and are carried northward by the prevailing winds. Eggs deposited by them give rise to a brood of moths which in turn fly further northward, and thus the worms are gradually found throughout the whole cotton belt, though with a considerable confusion between the various generations. At least seven generations occur on the Gulf Coast, and three at the northern limit of the species. Considering the number of eggs laid by each female and this number of generations, it may be readily perceived how such immense numbers of the caterpillars may arise by the latter part of the season, in a region where practically none remain over winter. If none was killed, the progeny of a single moth after four generations would amount to over 300,000,000,000 individuals, or if placed end to end, the third generation would be enough to encircle the earth at the equator over four times.

Enemies.—It is thus very fortunate that there are many deadly enemies of the cotton worms, which commence their warfare upon them with their first appearance in spring and continue it with increasing ardor throughout the season. One of the most effective of these is a minute little insect, *Trichogramma pretiosa*,

which develops within the eggs. Mr. H. G. Hubbard once observed that in Florida from 75 to 90 per cent of the fourth brood of eggs were destroyed by this parasite, while only three or four eggs in a hundred escaped in the sixth brood. Another of the most useful parasites, *Pimpla conquisitor,* was noticed as early as 1847 to destroy nearly all of the pupae of the last brood. The eggs of the *Pimpla* are laid upon the caterpillar, and the maggots enter the worm and feed upon its juices. It changes to a pupa as usual, but the pupa soon dies, and large numbers are thus killed. Several similar parasites prey upon the cotton worm, and it is to be regretted that we know of no way of encouraging their valuable work. The common insectivorous birds eat large numbers of the worms, especially when they are scarce in early spring, and they should be protected by enacting and enforcing most stringent laws against their wanton destruction.

Control.—The most commonly used and effective remedy is to dust the plants with Paris green. Dusting machines drawn by a team which will cover four rows at once are in common use. The dust may be applied with any of the powder guns, but it is most commonly applied to two rows at once by means of bags fastened at the ends of a pole and carried by a man on horseback, who can thus dust 15 to 20 acres per day. These sacks are about 10 inches long by 4 inches in diameter, open the whole length on one side and firmly sewed at the ends. Eight-ounce Osnaburg is the best cloth for the purpose. A strip of oak or strong wood about $1\frac{1}{2}\times 2$ inches, and 5 feet long, has a 1-inch hole bored through it 5 inches from each end, and to this the sack is tacked, fastening one of the edges of the opening to each of the narrow sides of the pole. The sacks are filled through the holes in the pole. When freshly filled a slight jarring will shake out a sufficient amount of the poison, but when nearly empty the pole should be frequently and sharply struck with a short stick or spaces will be missed. The poison has been found most effective without the admixture of flour, but if it is used, lighter cloth should be used for the sacks.

Besides the general use of Paris green there have been several

important factors which have aided in the control of the cotton worm, so that it is by no means as much of an enemy of the cotton crop as formerly. Among the most important of these, both from an entomological and general agricultural standpoint, is the diversification and rotation of crops, now coming to be more and more practiced by the progressive agriculturists of the South. This alone largely prevents the rapid spread of the pest. Since the seed has become such a valuable product of cotton, smaller varieties with many seeds and a short fibre are being grown, in contrast to the rank-growing, long-fibre sorts formerly preferred. Thus the rows are more open, the work of the worms is more readily detected and the poison more easily applied.

Other Caterpillars Injuring the Foliage

Several of our common caterpillars which ordinarily feed upon various weeds frequently attack cotton foliage in restricted localities and do more or less serious damage. They may be readily controlled by keeping down the weeds upon which they normally feed and multiply and by dusting the foliage as for the cotton worm as soon as they are noticed upon the cotton in any numbers.

Among the more common of these leaf-eating caterpillars is the Garden Webworm* (see page 406), which may be recognized by the fine silken web which it spins over the young plants. Another is the White-lined Sphinx Caterpillar,† a yellowish-green caterpillar with black eye-spots and faint stripes, varying to blackish with yellow spots, and distinguishable from most other cotton caterpillars by the horn, characteristic of sphingid caterpillars, at the tip of the abdomen. The Salt-marsh Caterpillar ‡ which is one of our best-known "woolly bear" caterpillars, covered with black and red hairs, has frequently stripped cotton of foliage in Texas, as does the Fall Army Worm (see page 118), when it becomes locally overabundant. Many other species might be mentioned which do more or less local injury.

* *Deilephila lineata* Fab. Family *Sphingidæ*.

† *Loxostege similalis* Guen. Family *Pyralidæ*.

‡ *Estigmene acræa* Drury. Family *Arctiidæ*

The Cotton Square-borer *

Just as the cotton squares commence to form they are often bored into by a small green caterpillar which many planters consider a stage of the bollworm and which others have called the "sharpshooter." This injury is often quite serious on a small area, as we have seen 10 per cent of the stalks entirely denuded of squares in small fields in Texas where this insect was abundant. The little caterpillars hollow out the squares in the same manner as does the bollworm, often destroying all of those on a plant knee-high and even boring into the tender stalk. The

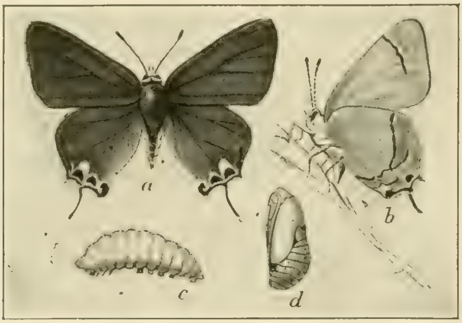


FIG. 176.—The cotton square-borer (*Uranotes melinus* Hbn.): *a*, adult; *b*, underwing of same; *c*, larva; *d*, pupa—natural size. (After Howard, U. S. Dept. Agr.)

caterpillars are bright green, oval, decidedly flattened, covered with short hairs which give them a velvety appearance, and with the head retracted under the front of the body, thus being quite unlike any stage of the bollworm. They are the larvæ of a dainty little butterfly (Fig. 176), of a bluish-black color, with dark reddish lustre, and with bright red spots on the posterior border of the hind wings, common around cotton-fields. The small yellowish, transparent eggs are laid on the leaves and stems of cotton, cow-peas, goat-weed, and various weeds, and the larvæ have also been found on hops, beans and cow-peas, seeming to

* *Uranotes melinus* Hbn. Family *Lycænidæ*.

prefer the latter to cotton. The eggs hatch in from two to five days, the larvæ become grown in a little over two weeks, and the pupal stage averages about ten days, so that the whole life cycle requires about a month in Central Texas, where there are three or four generations in a season.

Fortunately for the planter the large majority of the caterpillars are parasitized, over 90 per cent of the June generation having been thus destroyed.

Usually, therefore, it is hardly worth while to attempt to combat this insect, as it is not often seriously injurious year after year. Should remedial treatment be necessary, thorough dusting with Paris green or arsenate of lead would probably destroy most of them, as the young caterpillars, like the bollworms, feed to some extent upon the foliage before entering the squares.

"Sharpshooters" *

In late summer reports are frequent that cotton is being injured by "sharpshooters," especially on low land. These insects are reported to puncture the squares and bolls, causing them to drop prematurely, a small black speck showing the spot where punctured. The insect which has been most commonly credited with this work is the Glassy-winged Sharpshooter,† but with it are usually associated several near relatives with

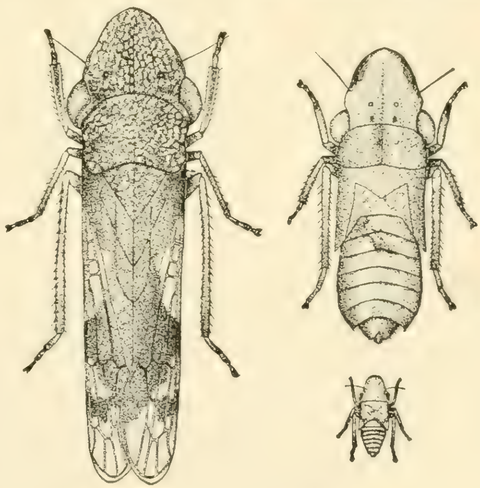
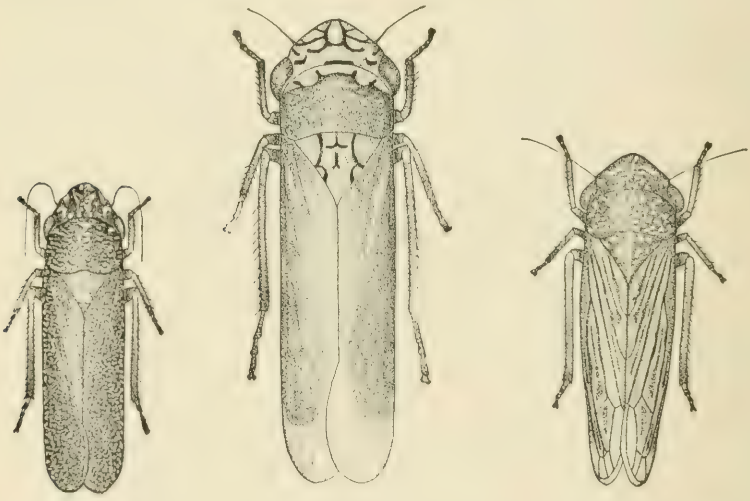


FIG. 177.—The glassy-winged sharpshooter (*Homalodisca triquetra* Fab.): adult at left, last stage of nymph at right, young nymph below—all enlarged. (Author's illustration, U. S. Dept. Agr.)

* Family *Jassidæ*.

† *Homalodisca triquetra* Fab.

similar habits.* Few planters are able to identify the cause of the supposed injury, but many know these insects as "dodgers," from their habit of quickly dodging to the opposite side of the stem when disturbed. Extensive observations and repeated experiments during two seasons failed to show the slightest evidence that these insects are ever injurious to cotton, though they are common upon it, the supposed injury being undoubtedly due to the physiological condition of the plant which causes a shedding of the fruit at the season when the supposed injury occurs.



a *b* *c*

Fig. 178.—Three cotton leafhoppers commonly called sharpshooters: *a*, *Aulacizes irrorata*; *b*, *Oncŏmetopia undata;* *c*, *Oncometopia lateralis*—much enlarged. (Author's illustration, U. S. Dept. Agr.)

The adult insects hibernate in rubbish on the ground near the food-plants and appear in early spring on the elm, hackberry, red-bud, cottonwood, willow, and the tender shoots of other trees, especially on bottom-land near streams. Here they suck the juices of the tender leaves and deposit their eggs in them. The eggs are laid in rows of ten to fifteen, side by side, just under the surface of the leaf, forming a blister-like mark. They hatch in a

* *Oncometopia undata* Fab., *O. lateralis* Fab., and *Aulacizes irrorata* Fab.

few days and the young bugs, or nymphs, are grayish or yellowish in color and resemble the adults except in the lack of wings. Two or three generations occur annually in Texas, and the insects are not common on cotton until midsummer. They are exceedingly fond of banana trees, sorghum and sunflowers, sometimes doing considerable injury to the latter, but there is no evidence for considering them pests of cotton.

The Cotton Leaf-bug *

This insect was the cause of considerable damage in northern

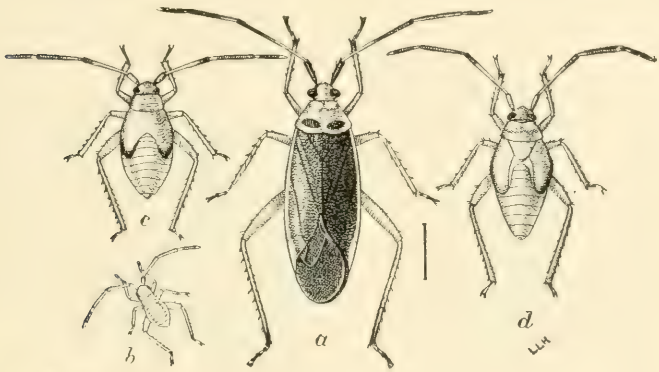


FIG. 179.—The cotton leaf-bug (*Calocoris rapidus*): *a*, adult; *b*, *c*, *d*, stages in growth of nymph; and cotton boll, showing spots injured by cotton leaf-bug all enlarged. (Author's illustration, U. S. Dept. Agr.)

Texas in the latter part of the season of 1904, and had been previously reported as a pest of cotton, though its injury had never

† *Calocoris rapidus* Say. Family *Capsidæ*

been general. It punctures the squares and bolls, either causing them to drop or making the bolls shrivel or decay when punctured. The feeding punctures in the bolls are indicated by small black spots, resembling diseased places, which gradually become larger and sunken, evidently due to some poisonous substance introduced by the beak of the insect as it sucks the juices of the boll. The bugs may be readily recognized from Fig. 179, and by the bright red spots just beyond the middle of the wing. The young are light green marked with red. Several generations of the insect occur annually, but its life history and habits are still unknown, and no means of combating it been devised.

Other Plant-bugs *

Several other species of plant-bugs cause similar injury by sucking the bolls and causing black spots, with shrinking or decay.

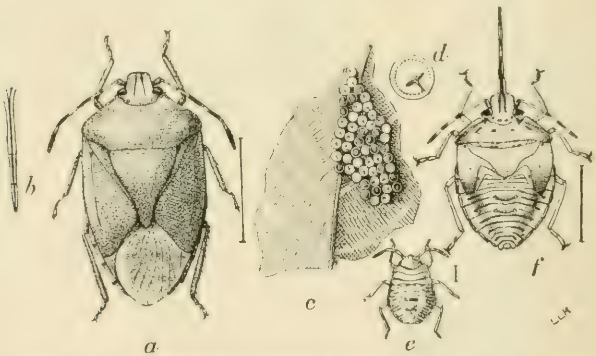


FIG. 180. The green soldier-bug (*Nezara hilaris*): *a*, adult; *b*, beak; *c*, eggs. *d*, end of egg more enlarged; *e*, young nymph; *f*, last stage of nymph. (After Chittenden, U. S. Dept. Agr.)

Among these are the so-called " pumpkin-bugs " or " stink-bugs," of which a large green species † is the most commonly injurious, while the blackish, leaf-footed plant-bugs,‡ which are more abundant on cucurbs, do similar injury.

* See A. W. Morrill, Plant-bugs Injurious to Cotton Bolls. Bulletin 88 Bureau of Entomology, U. S. Dept. Agr.

† *Nezara hilaris* Say. Family *Pentatomidæ*.

‡ *Leptoglossus oppositus* Say. Family *Coreidæ*.

"Cotton-stainer" *

The Red-bug or Cotton-stainer once did considerable damage to the bolls in Florida, Georgia, and neighboring parts of Alabama and South Carolina, but of late years has devoted most of its attention to oranges. Early in the season they stunted the bolls and made them abortive by sucking the sap; but the most serious damage was done later, when they entered the open bolls, "punc-

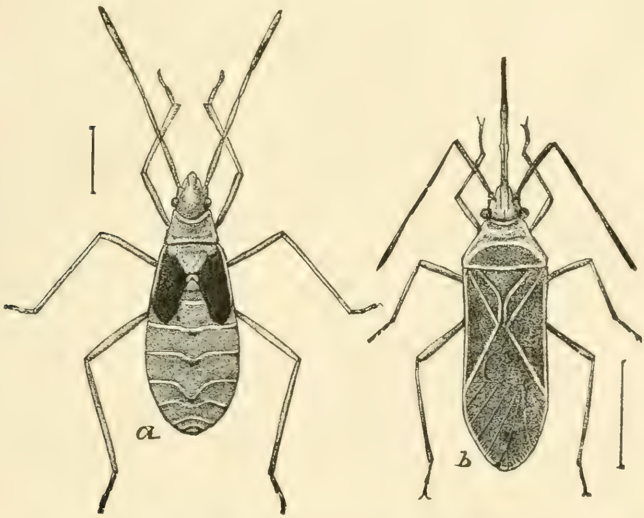


FIG. 181. The red bug or cotton-stainer (*Dysdercus suturellus*) enlarged. *a*, nymph; *b*, adult. (From "Insect Life.")

turing the seed and damaging the fibre" by their yellowish excrement. This indelible stain greatly depreciated the market value of the fibre, and was a vexing loss. Though never of commercial importance, it was found by experiments that a rich orange dye could be made from these insects, which could be easily fixed upon silks and woolens by an alum mordant. In winter these insects congregate in heaps of cotton-seeds, and by using these as traps the insects may be killed with hot water.

* *Dysdercus suturellus* H. Schf. Family *Pyrrhocoridæ*.

The Cotton Bollworm *

One of the most destructive and widespread pests of cotton is the bollworm, the same insect as the earworm of corn already described (page 181), which should be consulted for the life history and description. Throughout the cotton belt the moths of the third generation appear about August 1st. At that time the ears of corn have become too hard to furnish suitable food for the larvæ and the moths therefore lay their eggs on the cotton leaves, though if any late corn is in silk it is decidedly preferred. Thus during the month of August the cotton is often seriously injured by the caterpillars boring into the bolls, this injury being most serious in recent years west of the Mississippi and particularly in north Texas and Louisiana. The total damage to cotton is estimated at upward of $20,000,000 per annum. Though more or less damage is done by the fourth generation of worms, injury is rarely serious, as the numbers are greatly reduced by parasites and unfavorable weather conditions.

FIG. 182.—Bollworm at work on cotton bolls, boring into grown boll—slightly reduced. (After Quaintance and Brues, U. S. Dept. Agr.)

About two-thirds of the eggs on corn are parasitized by a tiny little insect hardly visible to the naked eye,† which

* *Heliothis obsoleta* Fab. Family *Noctuidæ*. See Farmers' Bulletin No. 290, U. S. Dept. Agr., by F. C. Bishopp and C. R. Jones and Bulletin 50, Bureau of Entomology, U. S. Dept. Agr., by A. L. Quaintance and C. T. Brues.

† *Trichogramma pretiosa* Riley.

becomes so abundant late in the season as to effectively check the increase of the pest.

Wasps are effective enemies of the bollworms, provisioning their nests with them. Several species of tachina-flies parasitize the caterpillars, while not a few are killed by a bacterial disease. One of the most important natural factors in reducing their numbers, however, is their own tendency to cannibalism, the larger

Fig. 183.—Bollworm boring into green tomato. (After Quaintance and Brues, U. S. Dept. Agr.)

caterpillars attacking and destroying the weaker with a consequent marked reduction in numbers.

Control.—As in protecting corn from this pest, the most effective means is the plowing of the land containing the pupæ in winter or late fall.

Early planting of early fruiting varieties of cotton, with a liberal use of fertilizers, and frequent cultivation, so as to hasten the maturity of the crop, will result in a good crop being made before the worst injury by the bollworm occurs. These cultural measures ensure the best crops even where there are no insects to be avoided, and as an early crop is less injured by almost all cotton insects, the planter should adjust his methods to secure earliness.

As the eggs are laid mostly on the cotton leaves and the little caterpillars nibble the surface before boring into the bolls, the poisoning of the foliage when the eggs are hatching will result in a very material reduction of the subsequent injury. Paris green has been most generally used, but probably powdered arsenate of lead will be found superior to it. Paris green has been used at the rate of 3 pounds per acre, applied either pure or diluted with lime or flour, using either a bag and pole, hand powder-gun or geared dusting machine. The dusting should be done while the plants are wet with dew. When not followed immediately by rain, two

Fig. 184.—Egg of bollworm; side and top views. Highly magnified. (From Quaintance and Brues, U. S. Dept. Agr.)

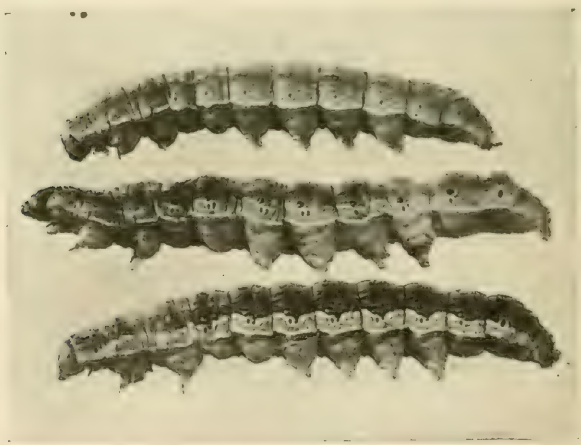


Fig. 185. Bollworms showing variation in color, upper larva green, middle rose, and lower, dark brown—twice natural size. (After Quaintance and Brues, U. S. Dept. Agr.)

applications should be sufficient, the first when the eggs commence to hatch in numbers, usually between July 25th and August 5th, and the second about a week later. If rains follow, the applications should be at once repeated.

Inasmuch as the moths prefer to lay their eggs on corn-silk, cotton may be very effectively protected by the use of strips of late corn and cow-peas, planted through the cotton so as to act as a trap crop. Leave vacant strips four or five rods wide across the

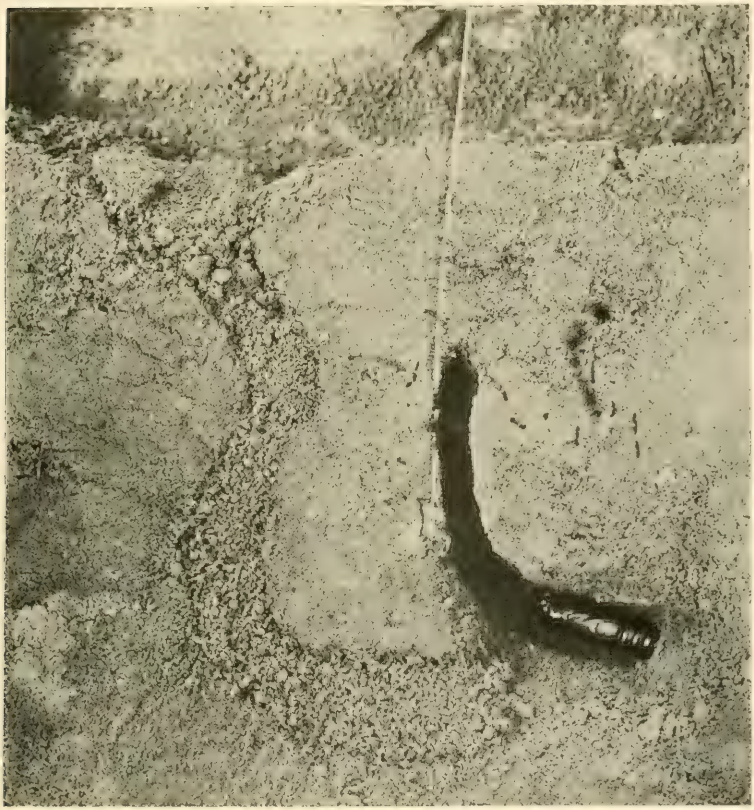


FIG. 186.—Pupa of the bollworm in its burrow in the soil, showing burrow made by the larva and filled in, and the exit burrow for the moth also made by the larva—natural size. (After Quaintance and Brues, U. S. Dept. Agr.)

fields when planting cotton. About June 1st plant these with alternate rows of Mexican June corn and cow-peas. This will bring the corn into silk about the first of August and will attract the

moths to lay their eggs upon it instead of the cotton, while the cow-peas will furnish both food and shelter to the moths. Corn should never be planted with cotton when cotton is planted, for instead of acting as a trap crop it merely furnishes food upon which the worms multiply during the early season and forces those of the third generation on the cotton. The strips of corn and peas should be cut as soon as the worms on them become fairly grown and the land plowed to destroy any which may have pupated. "On large plantations the planting of small areas of corn here and there in the fields is practicable. Such early crops as potatoes, oats, or wheat may be followed by corn and cow-peas with practically the same results."

Fig. 187.—The moth of the bollworm or corn ear-worm—enlarged one-fourth. (After Quaintance and Brues, U. S. Dept. Agr.)

The Cotton-boll Cutworm *

The larva of this species is a very common feeder upon the foliage of cotton and late in the season bores into the bolls in much the same manner as the bollworm. Cotton is but one of a long list of food-plants, however, as it is a common pest of sugar-beets, corn, wheat, cabbage, potato, asparagus, salsify, peach, raspberry, violet, cucumber, tomato, turnips, pea, rape, pigweed, cottonwood, and grasses according to Chittenden. It occurs commonly throughout the States east of the Rocky Mountains.

The moth has a wing expanse of about $1\frac{1}{2}$ inches, the fore wings being a dark, rich, velvety brown, marked with black,

* *Prodenia ornithogalli* Guen. Family *Noctuidæ*. See Sanderson, l.c., and F. H. Chittenden, Bulletin 27, n. s., Div. Ent., U. S. Dept. Agr., p. 64.

Fig. 188.—Tip of ear of corn showing eggs of bollworm or corn ear-worm on silks. (After Quaintance and Brues, U. S. Dept. Agr.)

yellow and ochreous as shown in the illustration, while the hind-wings are a light gray. The grown caterpillar is $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, and is quite variable in coloration, some being much darker than others, as shown in the illustration. The three whitish lines and the double row of triangular brown spots along the back of the lighter forms will easily distinguish this caterpillar from the bollworm.*

Life History. The life history has not been carefully observed

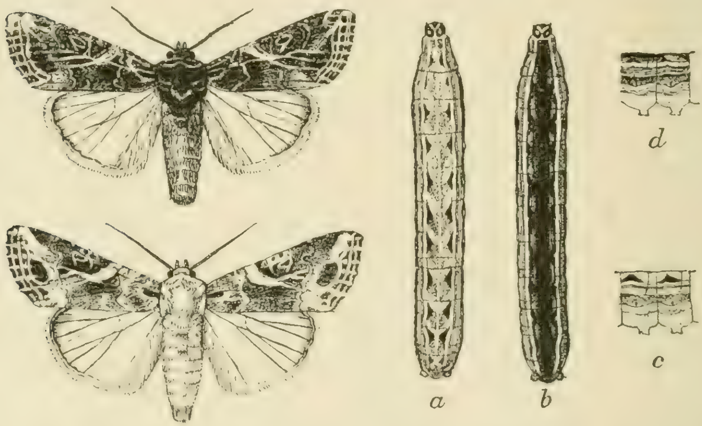


FIG. 189.—The cotton-boll cutworm (*Prodenia ornithogalli* Guen.): dark form of male moth above; pale form, female moth below; *a*, pale form of larva; *b*, dark form of larva; *c*, lateral view of abdominal segments of pale form; *d*, same of dark form. (After Chittenden, U. S. Dept. Agr.)

in the North, but from observations made by the writer in Texas the life history in the Gulf States seems to be as follows:

The winter is usually passed in the pupal stage in the soil, though possibly a few moths, emerging late, hibernate. The first brood of moths appears from the middle of May until the middle of June, mostly early in June. A second brood appears during the latter half of July, and a third late in August and during September. A few of the fourth brood may emerge in December, but most of them do not do so until the very early spring,

* See Chittenden, l.c., p. 36, for distinguishing characters of related species of *Prodenia*.

when they lay eggs upon various weeds on which the larvæ feed until cotton appears. The length of time occupied in the different stages is seen to be quite variable, but is approximately six days for the egg, twenty days for the larva, and thirteen days (usually ten to fifteen days) for the pupa—making a total of about forty days for the complete life cycle. Dr. Chittenden believes that there are two generations in the North and probably three in the latitude of the District of Columbia.

Control.—This species has not been sufficiently injurious on cotton to warrant extensive experiments in its control. Where it attacks young plants of cotton or other crops, it may be combated with the means suggested for other cutworms on page 85. Where it becomes injurious to the bolls, it might be controlled by thorough dusting or spraying with arsenicals, which would destroy the young larvæ while they are still feeding on the foliage.

The Mexican Cotton Boll Weevil *

Not since the invasion of the Mississippi Valley by the Rocky Mountain locusts in the 70's has any insect caused such ruin to any staple crop as has the boll weevil in the territory affected during the past ten years, and it is one of the factors in the recent high prices of cotton.

Like several of the worst insect pests of the South it is a native of Central America and came to us from Mexico, crossing the Rio Grande at Brownsville, Texas, about 1890. As early as 1862 the weevil caused the growers at Monclova, Mexico, to abandon cotton culture and when they again planted it in 1893, the beetle promptly appeared and destroyed the entire crop. It multiplied rapidly in south Texas, ruining the crops, and by 1895 had spread northward to a line extending eastward from San Antonio. Since then it has spread northward and eastward, about sixty miles a year, until in 1905 it had covered all of Texas and western Louisiana and is now found throughout the cotton area of those

* *Anthonomus grandis* Boh. Family *Curculionidæ*. See W. D. Hunter, "The Boll Weevil Problem," Farmers' Bulletin 344, U. S. Dept. Agr.; and Hunter and Hinds, Bulletin 51, Bureau of Entomlogy, U. S. Dept. Agr.

States and in Mississippi, Arkansas, Oklahoma, and Southwestern Alabama. There seems to be no reason why it should not continue to spread throughout the cotton belt.

Fig. 190.—The cotton boll weevil, natural size, showing variation in size and color.

In 1904, after an exhaustive study of all available data, the writer estimated the loss in Texas alone at $25,000,000, and that the pest had then cost the State $100,000,000. Owing to decrease in acreage and the general use of methods for preventing or avoiding injury, the injury has not increased proportionately to the spread of the pest, but the total annual loss is at least as much as in 1904, though no accurate estimates have been recently made for the whole territory affected.

Fig. 191.—The cotton boll weevil—enlarged.

Life History.—The parent of all this damage is a small brownish beetle about one-quarter inch long, varying from one-eighth to one-third, including the snout, which is about half as long as the body. Recently emerged weevils are light yellowish in color, but they soon become grayish-brown and later almost blackish. There are many nearly related weevils which very closely resemble the boll weevil, and only an entomologist can identify the species with certainty, but the two teeth at the tip of the femora of the fore-legs (Fig. 191), are the

FIG. 192.—Map showing spread of cotton boll weevil from 1892 to 1910. Prepared by Bureau of Entomology, U. S. Department of Agriculture. The line for each year was determined by field examinations by agents of the Bureau of Entomology, and in certain cases by the entomologists of the states concerned. In 1909 and 1910 the state entomologist of Mississippi furnished considerable information, as did the entomologist of Alabama in 1910.

most characteristic structure by which it may be distinguished. The boll weevil feeds only upon cotton, and weevils found feeding on other plants are certainly of other species.

Fig. 193.—Cotton square with bracts opened to show weevil at work on the bud, which shows a feeding puncture.

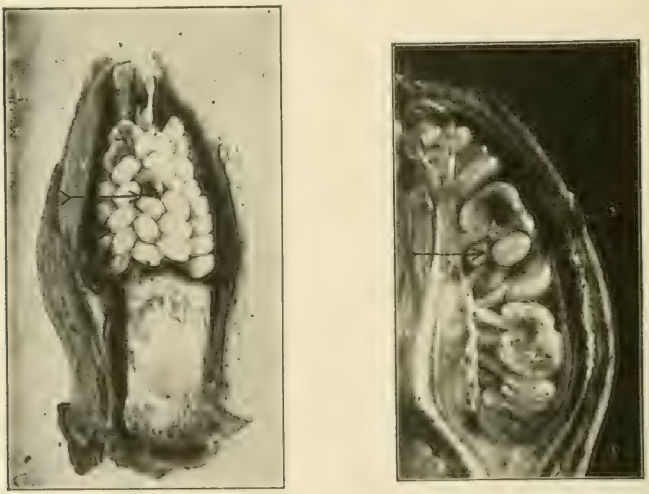


Fig. 194.—The cotton boll weevil; eggs among the anthers at points indicated by arrows, the cross-section at the right showing opening through which egg was deposited—greatly enlarged.

The weevils commence to emerge from hibernation soon after cotton is up and continue to emerge until the cotton commences to square freely. During the spring the beetles feed on the foliage,

particularly in the tender terminals, and as soon as squares are formed the females commence to lay their eggs in them. Each female lays an average of about 140 eggs, laying four or five a day. The female drills a small cavity in the square and in it deposits a small oval white egg, which hatches in about three days. The grub feeds upon the embryo flower, which usually fails to develop, and the infested square generally falls to the ground. In from seven to twelve days the larva is full grown and changes to the pupa, which stage lasts from three to five days. Thus

Fig. 195.—The cotton boll weevil, larva and pupa—enlarged.

from egg to adult requires from two to three weeks, though climatic conditions cause considerable variation in the length of time. The larva is a footless, white grub, with brown head, which lies curled up in the square as shown in Fig. 195, where the soft white pupa is also found. The adult weevils feed entirely during the day. Their length of life depends upon various conditions, but in the summer season the majority do not live over sixty days, while during the cooler part of the year those which hibernate live five or six months. Many squares are destroyed by the feeding punctures of the weevils. "The males feed upon the squares and bolls without moving until the food begins to deteriorate. The females refrain from depositing in squares visited by other females. This applies throughout most of the season, but late in the fall, when all the fruit has become infested, several eggs may be placed in a single square

or boll. As many as fifteen larvæ have been found in a boll. The squares are greatly preferred as food and as places for depositing eggs. As long as a supply of squares is present the bolls are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed. Whenever frost or other unfavorable weather causes the plants to cease putting on squares, the weevils attack the bolls. A

Fig. 196. Cotton squares broken open, showing the boll weevil larvæ within —enlarged.

conservative estimate of the possible progeny of a single pair of weevils during a season beginning on June 20, and extending to November 4, is 12,755,100."—Hunter. Although the weevil may develop from egg to adult in two or three weeks, it requires an average of about forty-three days for a complete generation, and there are probably not over four or five generations in a season.

With the first killing frosts, most of the immature stages developing are killed, though in south Texas they often develop

during the winter, and the adult weevils soon go into hibernation. When seeking places for hibernation the weevils migrate from field to field, and it is at this season that the principal migration of the pest takes place. The weevils may hibernate in hedges, woods, corn-fields, haystacks, or farm buildings, particularly about seed-houses or similar situations. Experiments have shown that Spanish moss forms an exceedingly favorable place for hibernation, and that many weevils pass the winter in it on trees some distance above the ground. Others may hibernate in the cotton-field, crawling into cracks, under grass, weeds, and trash, and into the empty cotton burrs, while in the more southern sections many hibernate in injured bolls. The weevils which hibernate most successfully do so outside of the cotton-fields. The number which survive the winter has been accurately determined under various conditions for several seasons, and depends upon the minimum temperature, the amount of moisture, and the kind of shelter. Thus in central Texas but 2 or 3 per cent survive in many normal winters, while in the open winter of 1906–07 11.5 per cent survived; in south Texas 15 per cent may survive, and in experiments made in Central Louisiana in 1908–09 with rather favorable conditions 20 per cent survived. The importance of reducing the number which survive the winter is evident.

FIG. 197.—Cotton boll weevils hibernating in locks of cotton removed from old bolls left on stalks over winter.

Natural Control.—If infested squares fall to the ground and lie on the unshaded, hot soil the larvæ or pupæ within them are soon killed. As many as 40 per cent of the immature stages have thus been found dead in many fields. The importance of wide rows

and varieties which produce little shade is therefore apparent, and it is evident that injury will be much less on dry upland soil, and much more severe in bottoms where the cotton grows rank and thick.

Over a score of parasites * prey upon the immature stages within the squares or bolls, and they seem to be increasing in numbers and effectiveness as they become adapted to living upon the weevil, as they are all native insects which prey upon nearly

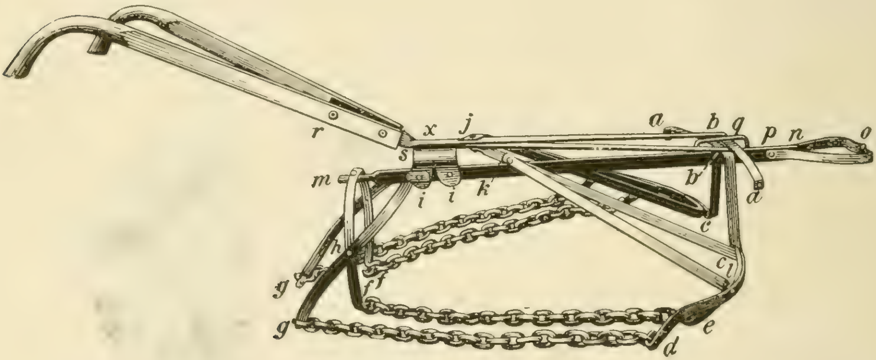


Fig. 198.—Chain cultivator for use in drawing weevil infested squares to center of row. (After Hunter, U. S. Dept. Agr.)

related species of weevils and other insects. As many as two-thirds of the immature stages have been destroyed by them in certain fields, though ordinarily not over 5 per cent of the total are parasitized. Several species of ants also feed on the immature stages, 20 to 30 per cent of those in fallen squares and bolls often being destroyed by them. The ants destroy many more in the fallen squares than in those hanging on the plants, so that the dropping of the squares aids their good work as well as exposes the squares to the heat of the sun.

Usually about 70 per cent of the infested squares drop, and in these 70 to 80 per cent of the immature stages are destroyed by natural causes.†

* See W. D. Pierce, Studies of Parasites on the Cotton Boll Weevil, Bulletin 73, Bureau of Entomology, U. S. Dept. Agr.

† See W. E. Hinds, Some Factors in the Natural Control of the Mexican Cotton Boll Weevil, Bulletin 74, Bureau of Entomology, U. S. Dept. Agr.

Control.—By far the most important measure in the control of the boll weevil is the destruction of the plants in the fall as soon as the cotton can be picked. This both destroys the weevils and prevents their increase. The stalks should be plowed out and burned as soon as possible. It is well to plow out all but a row here and there upon which the weevils will concentrate, then as soon as the piles are dry enough to burn, cut the remaining rows and burn at once. In this way the great bulk of the adult weevils and all of the immature stages in the squares and bolls are destroyed. The few escaping weevils will be starved out before the weather becomes cold enough for them to hibernate, or will be so weakened as to die in hibernation. Thus it has been shown by Professor Wilmon Newell, in Louisiana, that where the weevils were forced into hibernation on October 15th only 3 per cent survived the winter, but that when the destruction of the stalks was put off until after December 15th, 43 per cent survived, with proportional numbers at intervening dates. Furthermore, the development of the late broods which furnish the majority of the weevils which hibernate is effectually prevented. The removal of the plants also facilitates winter plowing, which aids in producing an early crop the next year. Many experiments and the experience of practical planters have shown that the destruction of the stalks in the fall is of primary importance in the control of the weevil, particularly upon bottom lands. Experiments made in Calhoun County, Texas, where the stalks were destroyed on 410 acres, showed an increase the next season of over one-quarter bale per acre as compared with fields where the stalks had been

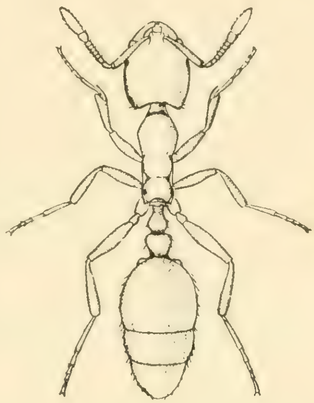


FIG. 199.—*Solenopsis geminata* Fab., a native ant which is a valuable enemy of the boll weevil—much enlarged. (After Hunter and Hinds, U. S. Dept. Agr.)

left standing, the benefit being worth $14.56 per acre, or over twenty-nine times the cost of the work. It is better to plow out the stalks than to cut them, particularly in the far South, as the stalks will frequently sprout out in the late fall and thus furnish

Fig. 200. *Bracon mellitor* Say, one of the most important parasites of the boll weevil larvæ—much enlarged. (After Hunter and Hinds, U. S. Dept. Agr.)

food for the late weevils, or will sprout in early spring and furnish food for those first emerging from hibernation. For the same reasons all volunteer cotton should be destroyed.

It is evident that the thorough defoliation of the plants by the cotton leafworm will secure much the same result as the destruction of the stalks, by removing the food supply of the weevil. Planters should not poison the leafworms, therefore, when they appear during the latter part of the season in fields injured by the weevil, for though formerly much dreaded they are now a great aid in preventing the increase of the weevil in fall.

It has been demonstrated that injury by the weevil is never so severe where cotton is planted after some other crop, this being due to the fact that the weevils do not fly far from their hibernating quarters in the spring.

By hastening the maturity of the crop, injury by the weevils may be avoided by making the crop before they have become most abundant. Everything possible should therefore be done toward hastening maturity, and this will be of importance in relation to the early destruction of the stalks in the fall. Land should be plowed in the winter and a good seed bed prepared. Cotton should be planted as early as possible with safety. A liberal use of commercial fertilizers will hasten the growth of the crop even on fairly fertile soils, and on poor soils their use will return a handsome profit. Early varieties of cotton should be planted, among the most satisfactory being, Rowden, Triumph, Cleveland Big Boll, Cook's Improved, King, Hawkins' Early Prolific, and Simkins. Seed should be secured from the originators of the varieties as far as possible. Chop out the plants as soon as possible. Frequent light cultivation will be found of the greatest importance in hastening the crop. Deep cultivation and cultivating close to the plants should be avoided as causing the squares to shed, and the old practice of "laying by" by running a broad sweep down the middles should be avoided. The lightest possible cultivation to keep the surface soil stirred is the best. All of these methods which aid in hastening the maturity of the crop are commonly called "cultural methods" of preventing loss from the weevil. They are not directed against the weevil itself, but are merely the best agricultural methods for securing an early crop, and on light upland soils attention to these methods will alone be sufficient to secure a good crop.

It has already been shown that the immature stages in squares falling on the hot soil will be killed by the heat. To aid in this the rows should be planted fairly wide apart, and varieties producing a minimum of shade are preferable, as are those which readily shed their squares when injured. As most of the squares drop beneath the plants where they are shaded, any means of scraping them into the centres of the rows will aid in their destruction. For this purpose a chain cultivator as described by Hunter (l.c.) (Fig. 198) has proven very efficient for this purpose. The chains may be attached to ordinary cultivators by special

attachments. An arm or projection that will brush the plant should be attached to whatever cultivator is used so that the squares will be knocked to the ground, as the effect of the heat is greater the earlier the squares drop.

During 1909 Professor Wilmon Newell and his assistants demonstrated at several places in Louisiana that the weevil may be successfully poisoned by the use of dry or powdered arsenate of lead, though previous experiments with dry Paris green and arsenate of lead as a liquid spray had not proven of practical value for various reasons. An increase of 71 per cent of the crop was secured on considerable areas and the results were duplicated by practical planters. Professor Newell recommends that the poison be applied first when the first squares appear and that five applications be given at weekly intervals. The poison must be applied by hand with a powder-gun so that it is blown into the squares. The first application requires about 2½ pounds per acre and the last 5 to 7 pounds. The cost for labor and materials will amount to from $5 to $7 per acre, but at this rate the operation will show a decided profit with the above amount of benefit as long as cotton sells at over 8 cents per pound. Although the use of powdered arsenate of lead is still in an experimental stage, it promises to become one of the most important means of combating the boll weevil, particularly in the river bottoms of the Mississippi basin, where conditions for the multiplication and hibernation of the weevil are particularly favorable.*

* See Newell and Smith, Circular 33, Louisiana Crop Pest Commission, Baton Rouge, La.

CHAPTER XIV

INSECTS INJURIOUS TO THE HOP-PLANT *

The Hop-plant Borer †

THE Hop-plant Borer is sometimes the occasion of a considerable loss to the hop industry, Mr. Chas. R. Dodge having estimated upon the basis of the census of 1879 that it then amounted to $600,000 annually in New York State alone. The moths have been taken from Ontario and New England south to the District of Columbia, and west to Wisconsin, and also from Colorado and Washington, but the larvæ have never become injurious in the hop-fields of the Pacific Coast. "It is probable that it is a northern form, and confined, as it seems to be, to a single food-plant, it will be found only where this plant is known to grow."

Life History.—Many of the moths emerge from the pupæ in the fall and hibernate over winter, while others do not transform till spring, passing the winter in the pupal stage in small cells in the ground near the roots of the plant which the larvæ have infested. The moths appear during May, and the females deposit their globular, yellowish-green eggs upon the tips of the hop-vines just as they begin to climb. "The egg hatches in a few days and produces a minute slender greenish larva, spotted with black, which immediately burrows into the vine just below the tip, and spends a part of its life in the vine at this point. The vine soon shows the effects of the insect's work; instead of pointing upward, embracing the pole readily and growing rapidly, the tip points downward, will not climb, and almost entirely ceases growing. This appearance is called by growers a 'muffle-head.' When the insect attains a

* "Some Insects Affecting the Hop-plant," L. O. Howard, Bulletin No. 7, n. s., Division of Entomology, U. S. Dept. Agr., p. 41.

† *Hydrœcia immanis* Grt. Family *Noctuidæ*.

length of about half an inch, or slightly less, it leaves the tip, drops to the ground, and entering the stem at the surface of the vine, feeds upward, interrupting the growth of the vine and lessening its vitality; the larva now changes color, and becomes a dirty-white, with a strong, deep reddish tint, with numerous black spots. The larva, now about an inch in length, and still slender, burrows downward to the base of the vine at its juncture with the old stock, and eating its way out, completes its growth as a subterranean worker;

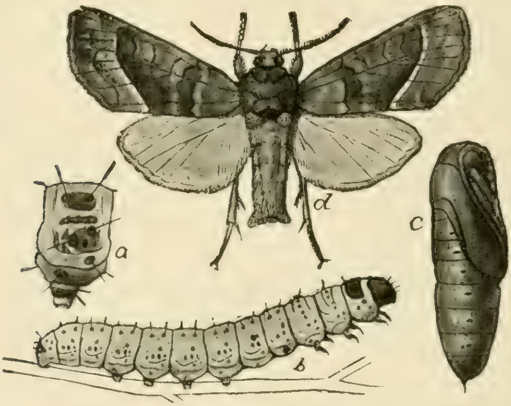


Fig. 201.—Hop-plant borer (*Hydræcia immanis* Grt.): *a*, enlarged segment of larva; *b*, larva; *c*, pupa; *d*, adult, natural size. (After Howard, U. S. Dept. Agr.)

it is in this state that it is best and most widely known as the hop 'grub,' and the ravages caused by it are most noted."*

The larvæ have mostly left the stems by the last of June and henceforth are mainly sap-feeders. Eating into the stem just below the surface of the ground and just above the old root, they rapidly grow fat upon the juices of the plant. These openings are gradually enlarged so that very often the stem is entirely severed from the root or is so slightly attached that the plant is badly stunted and yields few, if any, hops. The larvæ become full grown from the middle to the 20th of July and are then

* "Hop-insects," Dr. J. B. Smith, Bulletin No. 4, o. s., Division of Entomology, U. S. Dept. Agr.

"about two inches in length, fleshy, unwieldy, and very slow in their movements; they are of a dirty white color, speckled with fine, brownish elevated tubercles, each furnished with a single stout hair; the head is brownish and corneous, as is also the top of the first segment." (l.c.)

The larvæ now transform to pupæ in rough cells, close to the roots which they have infested, and the adult moths emerge during August or September, or the following spring. The adult moths are found, upon close examination, to be most beautifully marked, though not of a striking appearance at first sight. "The general color is a rosy brown, paler at the extremity of the wings. The darker central portion is shaded with dark velvety bronze and marked with two dull-yellow spots. The fore-wings are divided into three areas by narrow oblique transverse lines, edged outwardly with pink. The hind-wings are paler in color, crossed in the middle by a slightly darker line."—Howard l.c.

Remedies.—Two points in the life history of the insect afford opportunity for its control. The first is when the young larvæ are still in the tips and can easily be crushed by the fingers when tying the vines. "Muffleheads" should always be picked off and destroyed.

Early in June when the larvæ have left the inside of the vines it is well to remove all the soil from the base of the vine, down to the junction with the old root. The larvæ, which will not feed above ground, will go to the old roots, to which they will do but little injury. The roots should be left thus exposed for about a week. A handful of mixture of coal and wood ashes or ammoniated phosphate should then be applied to each and the plants hilled high. The plant will now send out new rootlets from the main root, and is able to secure necessary nourishment through them.

The Hop-louse *

Like many another aphid the Hop-louse has a most interesting life history, which has been fully ascertained in but recent years. During the winter the small oval black eggs may be

* *Phorodon humuli* Schr. Family *Aphididæ*.

found in the crevices and around the buds of the terminal twigs of plum-trees near infested hop-fields. From these hatch a

FIG. 202.—The hop-louse (*Phorodon humuli* Schr.): *a*, winter eggs and shrivelled skin of the sexual female which laid them; *b*, stem-mother, or first spring generation, with enlarged antenna above—all much enlarged. (After Riley, U. S. Dept. Agr.)

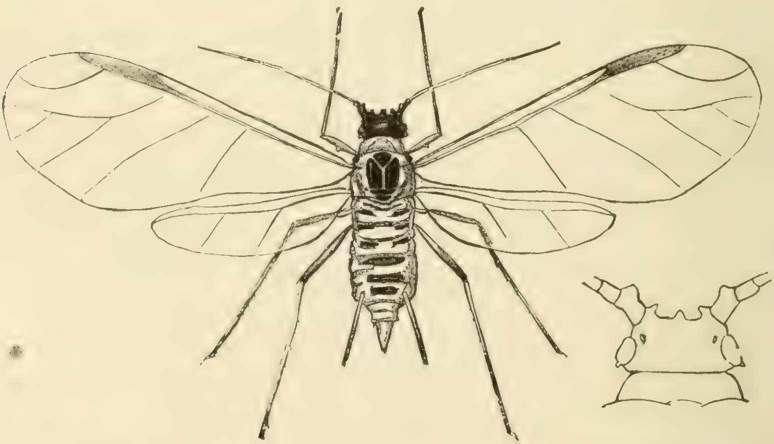


FIG. 203.—The hop plant-louse, third generation on plum—the generation which flies to the hop—enlarged; head below at right—still more enlarged. (After Riley, U. S. Dept. Agr.)

generation of females, known as "stem-mothers," during the following spring. The aphides of this generation differ in being stouter, with shorter legs and honey-tubes than those of any other

generation. Three generations feed upon the plum, the third becoming winged and flying to its favorite food in the hop-field.

Throughout the summer the aphides reproduce parthenogenetically. They "multiply with astonishing rapidity for from five to twelve generations, carrying us in point of time to the hop-picking season." "Each parthenogenetic female is capable of producing on an average one hundred young (the stem-mother probably being more prolific), at the rate of one to six, or an average of three per day, under favorable conditions. Each generation begins to breed about the eighth day after birth, so that the issue from a single individual easily runs up, in the course of the summer, to millions. The number of leaves (700 hills, each with two poles and two vines) to an acre of hops, as grown in the United States, will not, on the average, much exceed a million before the period of blooming or burning; so that the issue from a single stem-mother may, under favoring circumstances, blight hundreds of acres in the course of two or three months." *

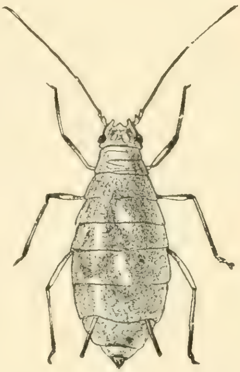


FIG. 204.— The hop plant-louse, true sexual female—enlarged. (After Riley, U. S. Dept. Agr.)

During September a brood of winged females are produced which fly back to the plum-trees, and in the course of a few days give birth to three or more young. These never become winged, but are the true sexual females which lay the winter eggs. The true winged males are developed during the latter part of the season and may be found pairing with the wingless females at that time, these being the only males during the year.

Remedies.—From a knowledge of the above life history several methods of treatment have been devised. By spraying plum-trees neighboring the hop-yard and infested with aphides while they are laying the eggs, during fall or in the spring

* Riley, The Hop-louse, Insect Life, Vol. I, p. 135.

before the winged generation appears, with some substance which will destroy them, the pest may be prevented from getting a start the next season. Spraying the trees during the fall is best, because a stronger or more caustic solution can then be applied without danger of injury to the tree. A winter wash of 1 pound of concentrated lye to 2 gallons of water may be used as a spray to advantage in killing a large share of the eggs, but should not be applied after the buds commence to swell in the spring. To

Fig. 205.—The hop plant-louse, male—enlarged. (After Riley, U. S. D. Agr.)

lessen the number of eggs all wild plum-trees in the neighboring woods should be destroyed. As soon as the crop is harvested, the hop-vines should be burned or thoroughly sprayed with kerosene emulsion, so as to kill off the males before they have been able to fertilize the females.

For spraying the plum-trees and hop-vines kerosene emulsion has been found very satisfactory, diluting the stock solution with 15 parts of water.

Fish-oil or whale-oil soap used at the rate of 1 pound to 8 gallons of water will prove an effective spray against the lice. Also see page 664.

The Hop-vine Snout-moth *

The larvæ of the Hop-vine Snout-moth sometimes become very formidable pests in the hop-field, appearing suddenly in large numbers and rapidly eating the foliage over a large area. They are not known to have any other food-plant than the hop and hence are only found where that plant occurs, though specimens have been taken from almost all sections of the United States, southern Canada, and British Columbia.

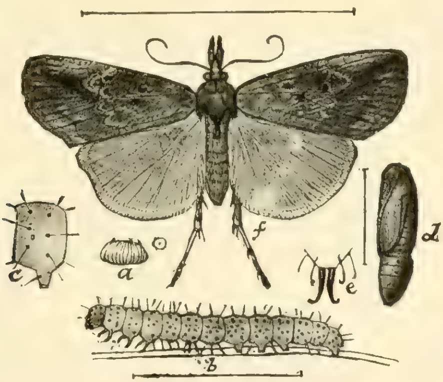


Fig. 206.—The hop-vine snout-moth (*Hypena humuli* Harr.): *a*, egg; *b*, larva *c*, segment of same; *d*, pupa; *e*, cremaster of same; *f*, adult—*a*, *c*, *e*, greatly enlarged, others slightly enlarged. (After Howard, U. S. Dept. Agr)

Life History.—It seems probable that the moths hibernate over winter, as they emerge in the fall, and lay eggs for the first brood early in the following May. The eggs are of a pale green color, and are deposited upon the under surfaces of the leaves, sometimes several upon a single leaf. The larvæ emerging from them become mature late in June and early in July. When full-grown the larvæ are slightly less than one inch long, and "of a green color, marked with two longitudinal white lines down the back, a dark-green line in the middle between and an indistinct whitish line on each side of the body. The head is green, spotted

* *Hypena humuli* Harr. Family *Noctuidæ*.

with black piliferous dots, and similar dots occur on each segment, arranged in two transverse rows." *

Before pupating the larva spins a thin silken cocoon, either among the leaves, under the bark of the poles, or at or slightly under the surface of the ground. The pupal stage occupies about ten days, and the moths emerge from the cocoons early in July. Another brood follows with a similar life history, the moths emerging late in August and in September and probably hibernating over winter.

The larvæ are known as "false loopers," on account of their bending the back slightly in creeping, which is due to their lacking the first pair of pro-legs.

Another species of the same genus (*Hypena rostralis*) affects hop-vines in Europe in the same manner and is very similar to the one above described.

Remedies.—The larvæ can be controlled by the use of any arsenical spray, which should be applied while they are still young.

Hop-merchants

The so-called "Hop-merchants," which here and there gleam from the vines are the chrysalids of two common butterflies, whose larvæ feed preferably upon hops. The chrysalids are normally marked with beautiful gold or silver spots, which sometimes become so diffused as to tinge the whole chrysalis. "An interesting superstition holds among hop-growers to the effect that when the golden-spotted chrysalids are plentiful the crop will be good and the price high, while if the silver-spotted ones are plentiful and the golden-spotted ones are scarce the price will be low."—Howard, (l.c.).

The Semicolon-butterfly †

The common names of these two butterflies indicate the most striking mark of distinction between them. *P. interrogationis* bears a silver mark like a semicolon or interrogation point upon

* Howard, l.c.

† *Polygonia interrogationis* Godart. Family *Nymphalidæ.*

the under side of the hind wings (Fig. 207), while *P. comma* has the same mark without the dot, which thus resembles a comma (Fig. 208).

The Semicolon-butterfly is common throughout the United States east of the Rockies, and especially in hop-growing regions. It hibernates over winter and is among the first butterflies to be seen in early spring, when it is often attracted to the flowing sap

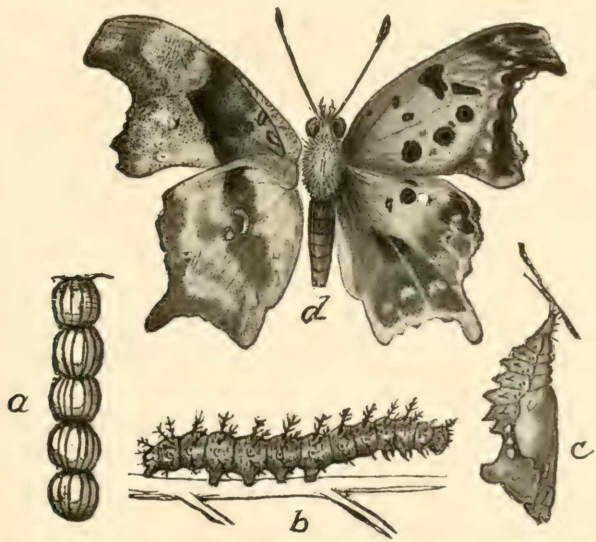


Fig. 207.—The semicolon-butterfly (*Polygonia interrogationis*): *a*, egg-chain; *b*, larva; *c*, chrysalis; *d*, adult—all natural size except *a*, which is greatly enlarged. (After Howard, U. S. Dept. Agr.)

of newly cut trees. The eggs are laid late in May or early in June, usually upon the under surface of the leaves of elm, blackberry, or nettle, either singly or in pendent columns of from two to eight. They hatch in from four to eleven days and the larvæ grow quite rapidly.

When full grown the larva is an inch and a quarter long. The head is reddish-black, somewhat bilobed, each lobe being tipped with a tubercle bearing five single, black-pointed spines, and covered with many small white and several blackish tubercles. The

body is black, thickly covered with streaks and dots of yellowish white; the second segment is without spines, but with a row of yellowish tubercles in their place; the third segment has four branching spines, all black, with a spot of dark yellow at their base; and on the fourth segment are four spines, as there are on all the others, excepting the terminal, which has two pairs, one posterior to the other. The spines are yellow, with blackish branches, excepting the terminal pair, which are black; and there is a row of reddish ones on each side. The under surface is yellowish gray, darker on the anterior segments, with a central line of blackish, and many small black dots.

The chrysalis is ash-brown, with the head deeply notched, and with eight silvery spots on the back; this stage lasts from eleven to fourteen days and the butterflies emerge in July. These lay eggs for another brood late in July and throughout August, mainly upon the hop-plants, where they are to be found. When the caterpillars of this brood are numerous they sometimes do considerable damage to the foliage, but both this and the following species are ordinarily prevented from becoming overnumerous by several parasites of the eggs and larvæ. Only when for some reason conditions are unfavorable to the development of its parasites does either species become especially abundant. In fact, Dr. J. B. Smith, who made extensive observations upon hop-insects in 1883, states "that not one in ten of the insects ever attains the butterfly state."

The chrysalis stage of the second brood is somewhat longer than the first, sometimes lasting twenty-six days, and the butterflies emerge from the latter part of August until the end of October, and at once seek quarters in which to hibernate over winter.

Both this species and *P. comma* are dimorphic, the winter and summer forms differing in both sexes in both the upper and lower aspects of the wings. In the South, where from three to five broods occur in a season, both forms are usually found in the second and third broods, the summer form, *var. umbrosa*, gradually decreasing until all of the fourth brood are the hibernating winter form, *var. fabricii*.

The Comma-butterfly *

The Comma-butterfly is most common throughout the East from New England to North Carolina and Tennessee, though occasionally found as far west as Wisconsin, Iowa, Nebraska, and Texas.

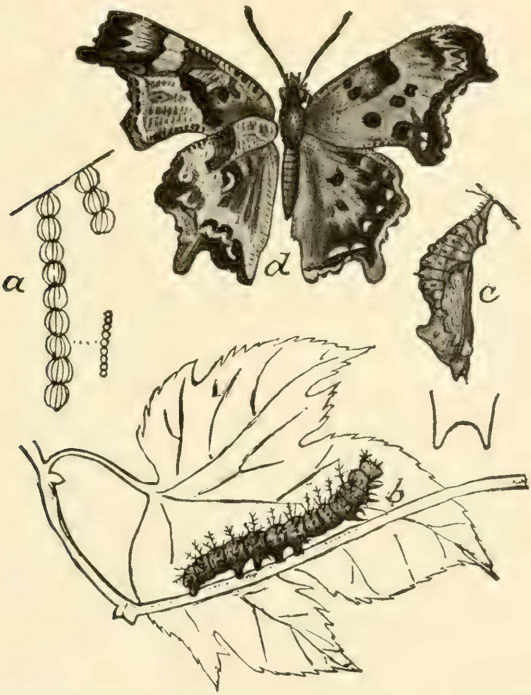


FIG. 208.—The comma-butterfly (*Polygonia comma*): *a*, egg-chain; *b*, larva; *c*, chrysalis; *d*, adult—all natural size, except *a*. which is greatly enlarged. (After Howard, U. S. Dept. Agr.)

Its life history is practically the same as that of the species just described. The larvæ of the first brood sometimes seriously damage young elm-trees which have been but recently reset, by eating them bare of the foliage. The winter form hibernates about a month earlier, being rarely seen in October. As a rule a similar

* *Polygonia comma* Harr. Family *Nymphalidæ*.

dimorphism occurs, the hibernating form being known as *var. harrisii* and the summer form *var. dryas*, though the distinction is not as marked in this species.

The half-grown larva is black, with a yellowish stripe along the side from the third segment, and with yellow stripes across the back, and spots of the same color at the base of the dorsal spines, which are yellow tipped with black. The mature caterpillar is white, mottled, or striped with gray or ashen, and with red spiracles.

The butterflies of both species are of a rich brown color, marked with black and tipped with lilac above, and of a much darker purplish brown with the characteristic silver spots beneath, which are well indicated in the illustration.

Remedies. Spraying with an arsenical will destroy the larvæ when such treatment becomes necessary.

CHAPTER XV

INSECTS INJURIOUS TO POTATOES AND TOMATOES

The Potato Stalk-borer *

In some sections this insect has rivaled the famous Colorado potato-bug in the damage it has inflicted upon potato-vines. It was recorded as badly damaging the crop in Iowa in 1890,

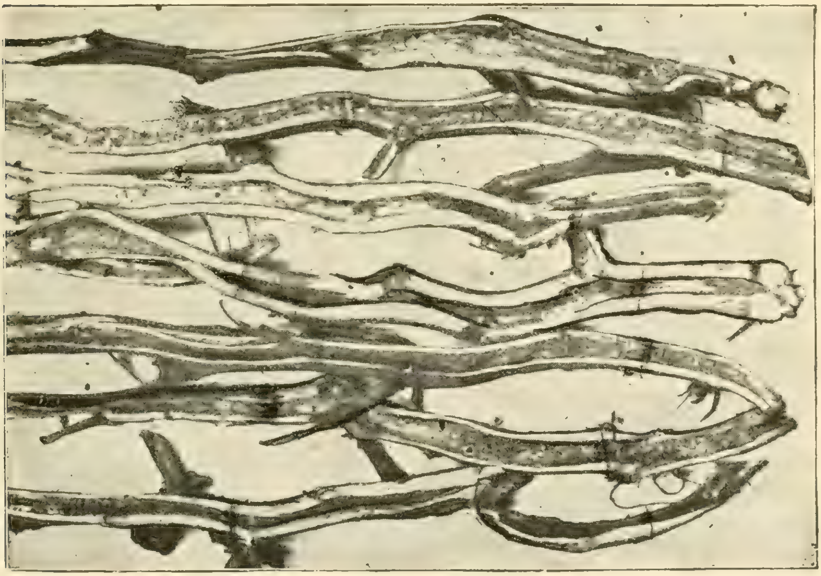


Fig. 209.—Work of potato stalk-borer in potato-vines. (After J. B. Smith.)

and was found by Dr. Riley in Missouri as early as 1869. The beetles were first noted in New Jersey in 1895, and have been injurious in Maryland and most of the Middle States.

Life History.—The grubs, which bore into the stalks of the vines,

* *Trichobaris trinotata* Say. Family *Curculionidæ*.

are the larvæ of some small ashen-gray beetles which appear early in spring and into June. These beetles are about one-fourth of an inch long, with a long, black beak or snout, and are marked at the base of the wing-covers by three black spots which give the insect its specific name, *trinotata*. Each beetle punctures a small hole in the base of a stem by means of its beak, hollows out a small cavity, and there lays a single small, oval, whitish egg. From these eggs some small, white grubs with brown heads hatch in a few days and commence to bore into the stalk. These grubs keep eating, either in the main stalk or branches, from August 1st to September 1st,

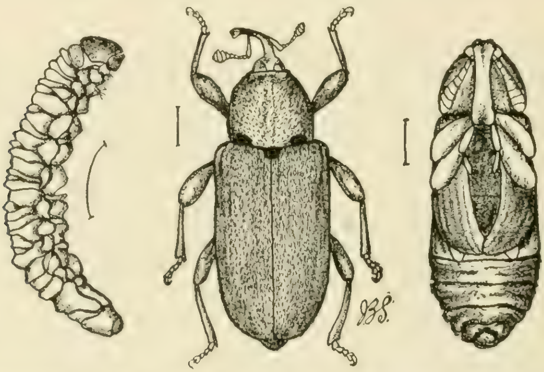


FIG. 210.—Potato Stalk-borer (*Trichobaris trinotata*). Larva, pupa and adult. (After J. B. Smith.)

when they have become full grown. At this time the grubs are about one-half an inch long, of a dirty white or yellowish color, with a yellowish-brown, horny head, and without legs. About the middle of August, as a general rule, the grubs construct small, oval cocoons of chips and fibres in the stalk of the vine near the surface of the soil, and there transform to the pupæ. During late August and September the mature beetles shed the pupal skins, in which they have remained dormant for the last few weeks, but remain in the vines during the winter, and do not come forth till the following spring.

Remedies.—On account of its internal feeding habits no poison can be successfully used against this pest, and the only remedy,

but a good one, is to rake up the vines and burn them as soon as the potatoes have been dug. As this insect also feeds upon the Jamestown weed, horse-nettle, and other weeds of the Nightshade family, or *Solanaceæ,* they should be kept cut down very closely. When the grubs are noticed in the plants, a good allowance of fertilizer will do much to quicken growth and thus enable them to mature a crop.

The Stalk-borer *

This species may well be called *the* stalk-borer, for it not only tunnels the stalks of potatoes—being often called the potato stalk-borer—and tomatoes, but frequently infests corn, cotton and a long list of garden crops, grains, grasses, flowering plants, and various common weeds. Apparently the latter, such as ragweed, cocklebur and the like, are its normal food plants, and when they are destroyed or where more tender cultivated plants are near by, it attacks whatever is available. Two or three nearly related species have very similar habits.

The adult moth (Fig. 211) is a fawn-gray or mouse color, with the outer third of the fore-wings paler and bordered within by a whitish cross-line.

Life History.—The eggs are laid in the fall on the stems of weeds and grasses, in masses of fifty or sixty, near the ground. They are about one-fiftieth inch in diameter, circular, grayish in color, with radiating ridges. They hatch in late May in southern Minnesota and the young caterpillars at once commence to mine small galleries in the leaves of the food plants, soon riddling the leaves. In a few days they work down to the bases of the leaves and enter the stalks, which they tunnel out and not infrequently leave one plant and migrate some little distance before entering another. Infested plants are readily recognized by the wilting of the parts above the larva, the work in corn being particularly noticeable and having given the local name of "heart-worm." The larvæ become full grown about the first of August. They are readily recognized by the peculiar

* *Papaipema nitella* Gn. Family *Noctuidæ.*

markings of the body (Fig. 211, *b*). The larva is about an inch long and varies from purplish to whitish brown, and is marked with five white stripes, one along the middle of the back, and two on each side. These sides stripes are absent on the first four segments of the abdomen, giving the larva an appearance as if it had been pinched or injured there. As the larva matures the stripes become fainter. When ready to pupate the larva cuts a

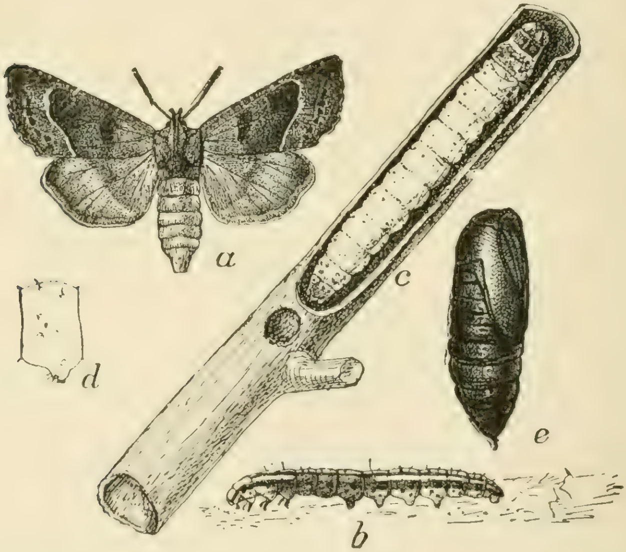


Fig. 211.—The stalk-borer (*Papaipema nitella* Gn.): *a*, adult; *b*, half-grown larva; *c*, mature larva in burrow; *d*, side of one of its segments; *e*, pupa—all slightly enlarged. (From Chittenden, U. S. Dept. Agr.)

hole through the side of the stalk, and then transforms to the brown pupa in the lower part of the stalk. The pupal stage lasts about two or three weeks, and the moths emerge in late August, there being but one generation a year.

Usually the injury to crops is only in the outer rows, to which the larvae have migrated from weeds growing along the edges, or in fields which have been weedy in early spring, or where the weeds have been allowed to get a start before being cultivated out.

Control.—From the life history and habits it is obvious that clean farming is the only method of effectual control. The destruction of weeds and fall plowing should prevent any general injury. Usually the injury is but local, and fortunately the caterpillars are attacked by numerous parasites which aid in their control, sometimes to the extent of killing 70 per cent of them. In small gardens the prompt destruction of infested plants will prevent the caterpillars from migrating to others. Where weeds are infested in or near a crop they should be destroyed as soon as cut, for if left on the ground the larvæ will promptly migrate to the nearest plants. Where fields are kept clean of weeds there will be little trouble.*

The Potato Tuber-worm †

The most serious pest of the potato in California is the Tuber-worm, which in tobacco regions of the Southern States is known as the "split worm" or leaf-miner (see page 237). Not infrequently 25 per cent of the crop is lost in infested regions in California, injury occurring both in the fields and to the tubers in storage. As the pest is carried in the potatoes and breeds in storage throughout the warm winters of California, and when exported across the Pacific, it is necessary to closely inspect potatoes from infested regions. Although no injury to potatoes has occurred outside of California, and though the insect probably could not exist in the North, it may well be guarded against in the Southern States, where it is a common tobacco pest.‡

Moths which have developed from larvæ working in stored potatoes are on the wing when young potatoes are up, and lay their eggs at the base of the leaves. The young larvæ bore into the stalks, often causing the plants to wilt and die. On older

* See Forbes, 23d Report State Entomologist of Illinois, p. 44; Washburn, 12th Report State Entomologist of Minnesota, p. 151; Journal Economic Entomology, III, p. 165; Smith, Report N. J. Agr. Exp. Sta. for 1905, pp. 584–587.

† *Phthorimea operculella* Zell. See W. T. Clarke, Bulletin 135, California Agr. Exp. Sta.

‡Recently serious injury by this insect has been reported to potatoes near Hallettsville, Texas.

plants or when the stalks harden, the larvæ leave the stalks and enter the tubers, particularly where they may be exposed. Where potatoes are exposed by being insufficiently covered the moths will lay their eggs directly upon them, as they also do upon potatoes exposed in the field after digging.

Most of the observations upon the life history seem to have been made upon the insect when breeding in stored potatoes. The eggs are about one-fiftieth inch long, oval, white, and laid singly or in pairs, about the eyes of the potatoes, or in similar rough places, where they are seen with difficulty. They hatch in a week or ten days, and the young larvæ are about one-twenty-fifth inch long of a transparent white color. The larvæ burrow beneath the skin and bore into the potatoes, filling their burrows with frass and excrement, which soon give rise to various rots which cause the destruction of the tuber, already rendered unfit for food by the burrows. The larvæ become full grown in about six or seven weeks. They are then about a half inch long. The head is dark brown; the first segment is an old rose color, with dark brown shield on the back; the second segment is a similar clouded pink; while the third and succeeding segments are a clouded white, often becoming yellowish or greenish, according to the food eaten. The full-grown larva returns to the mouth of the burrow and there makes its cocoon, or leaves it and forms the cocoon in some depression of the potato or in some crack of the storage vessel or in a fold of the bag. The cocoon is constructed quite differently from that of most moths as described by Mr. Clarke. The larva first makes a mat of silk and then forms an outer layer to the surface of which particles of dirt and rubbish adhere so that the cocoon is well concealed. When this pocket-like cocoon is finished the larva enters it and closes the open end and in it transforms to the pupa. The pupal stage lasts about two weeks, so that the complete life cycle requires from nine to twelve weeks, there being several generations during the year, according to the temperature.

Control. As the insect breeds on various common weeds of the Nightshade family (*Solonaceæ*), it is important that they be

destroyed wherever found. Seed potatoes must be free from the larvæ, or they will soon give rise to moths which will infest a whole field. When young plants are found wilting, the infested stalks should be cut and destroyed as soon as possible to prevent the further development and spread of the pest. Care should be taken in cultivating to hill up the soil, or thoroughly cover the tubers, so that they are not exposed. After digging, the potatoes should not be left exposed in the field any longer than is absolutely necessary and should not be covered with the tops to shade them, as is often done, as this furnishes a shelter for the moths and induces oviposition upon the tubers. Infested fields should have the stalks and all rubbish and refuse thoroughly raked up and burned as soon as possible, or sheep and hogs may be turned into the fields to destroy the stages which may be left in the vines or in the soil. Where fields have been flooded for two or three weeks after the crop has been dug, they have been entirely freed of the pest. For the treatment of stored potatoes, fumigation with carbon bisulfide in a tight room seems to be the only satisfactory method. This should be done as described for grain insects (see page 57). The tubers should be fumigated as soon as stored, and the treatment should be repeated at intervals of two weeks, four or five fumigations being recommended to entirely free the potatoes of all stages. Obviously it will be important to sort over infested tubers and remove all which are materially injured to prevent the increase of rot in others.

Colorado Potato-beetle *

First and foremost among the enemies of the potato-grower stands the Colorado potato-beetle—the insect which in the early seventies, on account of our ignorance of it, was made an entomological bugbear. But " there's no great loss without some small gain," and we may be thankful that the invasion of this beetle also brought about the use of Paris green, an insecticide which has

* *Leptinotarsa decemlineata* Say. Family *Chrysomelidæ.* See F. H. Chittenden, Circular 87, Bureau of Entomology, U. S. Dept. Agr.

since saved millions upon millions of dollars to the American farmer. Thus, with an effectual remedy which is now used where this pest occurs as regularly as potatoes are planted, "familiarity has bred contempt," and to-day we have but little fear of its attack.

History.—As is probably known to most of the older generation who watched its spread eastward, the Colorado potato-beetle, as its name indicates, was a native of the Rocky Mountain region, and until about 1855 was satisfied with feeding upon various com-

FIG. 212.—The Colorado potato-beetle (*Leptinotarsa decemlineata* Say.): *a*, eggs; *b*, larva; *c*, pupa; *d*, beetle; *e*, elytra or wing-cover of beetle; *f*, leg of beetle. (After Riley.)

mon weeds of the same genus as the potato-plant, principally *Solanum datura*, and closely allied genera. But with the settlement of this country and the introduction of the Irish potato, these bugs also began to take advantage of the fruits of civilization and transferred their feeding-grounds from the roadside to the potato-patch, and rapidly spread eastward from one to another, as well as being transported in the shipping of the potatoes.

Thus, in 1859 they had reached a point one hundred miles west of Omaha, Neb.; five years later they crossed the Mississippi into Illinois; and they advanced steadily eastward till recorded among

the Atlantic States in 1874. Though slow to be introduced into some few sections of the country, it is safe to assert that this pest may to-day be found almost wherever the potato is grown in the United States or southern Canada.

Life History.—During October the beetles enter the earth and there hibernate till the warm sunshine of April or May brings them forth. As soon as the young plants appear, the female beetles deposit their yellow eggs upon the under side of the leaves near the tips, each female laying an average of about five hundred eggs during the course of a month. Meanwhile the beetles have done considerable damage by eating the young and tender plants. In about a week there hatch a horde of very small but very hungry larvæ, which fairly gorge themselves with potato-foliage and increase in size with astonishing rapidity. In two and a half to three weeks, after having eaten an amount of food out of all proportion to their size, the larvæ become full grown, and enter the earth, where they form smooth, oval cells, and transform to pupæ. In a week or two the adult beetles emerge from the pupal skins and after feeding for a couple of weeks, deposit eggs for a second generation, which develops in the same way, and the beetles from which hibernate as already described. Throughout the territory where the beetles are most injurious there are two generations a year, but further south there is evidence of at least a partial, if not complete, third generation, and in the northern range of the species there is but one generation a year.

FIG. 213.—*a*, beak of predaceous bug; *b*, *Podisus spinosus* Dall.; *c*, beak of plant-feeding bug. (After Riley.)

Natural Enemies.—One of the chief agencies to prevent the excessive multiplication of this pest is the weather. Thus, Professor Otto Lugger records that in Minnesota, late in the fall of 1894, the beetles were lured from their winter quarters by a few warm days, and most of them subsequently perished from hunger or frost. In addition to this during the late summer of

1894 there was an excessive drouth, so that but few of the second brood matured. Thus in 1895 there were very few of the insects to be seen.

Among the birds, the common crow, the red-breasted grosbeak, and turkeys often feed upon this pest to a considerable extent.

Probably the most destructive insect-parasite of the larvæ is a Tachinid-fly known to science as *Lydella doryphoræ* Ril., which rather closely resembles the common house-fly, both in size and color. A single egg is laid on a potato-bug and from it hatches a small, footless maggot which burrows inside the bug. When the larva enters the earth, the effect of the maggot's work becomes apparent, and instead of transforming to a pupa and beetle, it shrivels up and dies; but the maggot itself contracts into a hard, brown pupa, from which the fly eventually emerges. Thus in 1868, when first noted by Dr. C. V. Riley, he asserted that in Missouri fully 10 per cent of the second brood and one-half of the third were destroyed by this parasite.

Many of our common lady-bird beetles and their larvæ check the pest by feeding upon the eggs. Several predaceous bugs, particularly the spined soldier-bug (*Podisus spinosus* Dall.) (Fig. 213) are of value in destroying the larvæ, into which they thrust their short, powerful beaks, and then suck out the juices of the body, leaving an empty skin. One or two of these closely resemble the common squash-bug (*Anasa tristis* De G.), but are really very dissimilar, and whereas the beaks of the predaceous forms are short and thick, as in Fig. 213, *a*, those, of plant-feeders, like the squash-bug, are long and slender, as in Fig. 213, *b*.

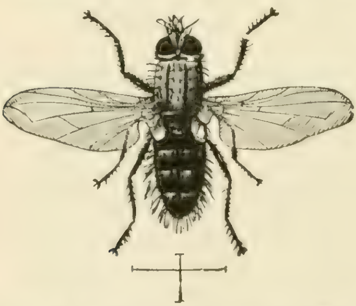


FIG. 214.—Tachinid parasite of Colorado potato-beetle (*Lydella doryphoræ* Ril.). (After Riley.)

Several species of ground-beetles are often found preying upon the larvæ and beetles, but, unlike the bugs, attack them by means

of their powerful biting jaws. These beetles are also exceedingly beneficial in feeding upon many other injurious insects, and are among the farmers' best insect friends (Fig. 215).

Remedies.—As an artificial remedy for this pest, Paris green has long been proven to be both effectual and practical. For small areas it may be used dry by mixing it with fifty times its weight of dry flour, land-plaster, or air-slaked lime, and should be applied while the plants are still wet with dew, either by a perforated can, or, better, by one of the improved powder-guns such as Leggett's, by which two rows of plants may be powdered at once. On larger areas spraying will be found more satisfac-

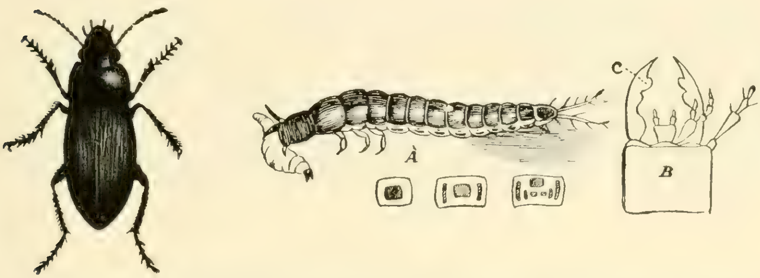


Fig. 215.—Murky ground-beetle (*Harpalus caliginosus*); *a*, its larva; *b*, head of larva showing mouthparts. (After Riley.)

tory. One pound of Paris green and 1 pound of freshly slaked quicklime to 50 gallons of water will kill all the larvæ, but often 2 to 3 pounds are necessary to destroy the beetles.

Many growers now prefer to use arsenate of lead at from 3 to 5 pounds to the barrel, as there is no danger of burning the foliage with it, and it is much more adhesive. Where Bordeaux mixture is not used the arsenate of lead is much preferable on account of its superior adhesiveness. Where Bordeaux mixture is used, arsenite of lime, or arsenite of lime made with soda, may be used, but these homemade arsenicals should not be used alone, on account of their burning the foliage.

The vines should be sprayed first when they are a few inches high, and the spraying repeated once or twice at intervals of ten

days or two weeks. The larvæ are so easily killed by arsenicals that potato growers no longer fear their work, but large quantities of Paris green are wasted by careless application, and by dusting unduly large amounts with poor apparatus, which not infrequently results in burning the foliage. For small areas a bucket or knapsack pump will be found satisfactory, but for over an acre a barrel pump with a row attachment will prove more economical, and for over ten acres a geared machine spraying several rows at once will be needed. Cleaning up the vines and plowing potato land in the

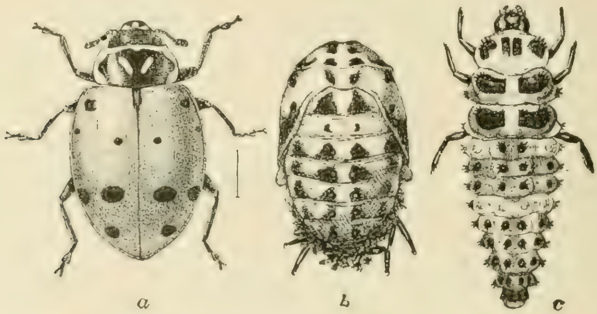


FIG. 216.—The convergent ladybird (*Hippodamia convergens*): *a*, adult; *b*, pupa; *c*, larva; enlarged. (After Chittenden U. S. Dept. Agr.)

fall after the crop has been harvested will aid in reducing the numbers of the hibernating beetles.

Flea-beetles *

While the potatoes and tomatoes are but a few inches high they are often attacked by myriads of small black beetles, which from their power of making long quick jumps are known as flea-beetles. They soon riddle the foliage, often so badly that the plants wilt, and replanting is necessary, particularly with tomatoes.

Several species are known to attack the potato, the two most common being the potato or cucumber flea-beetle (*Epitrix cucumeris* Harris) and one which Professor H. A. Garman has styled the Southern Potato Flea-beetle (*Epitrix fuscula*). The Tobacco Flea-

* Family *Chrysomelidæ*.

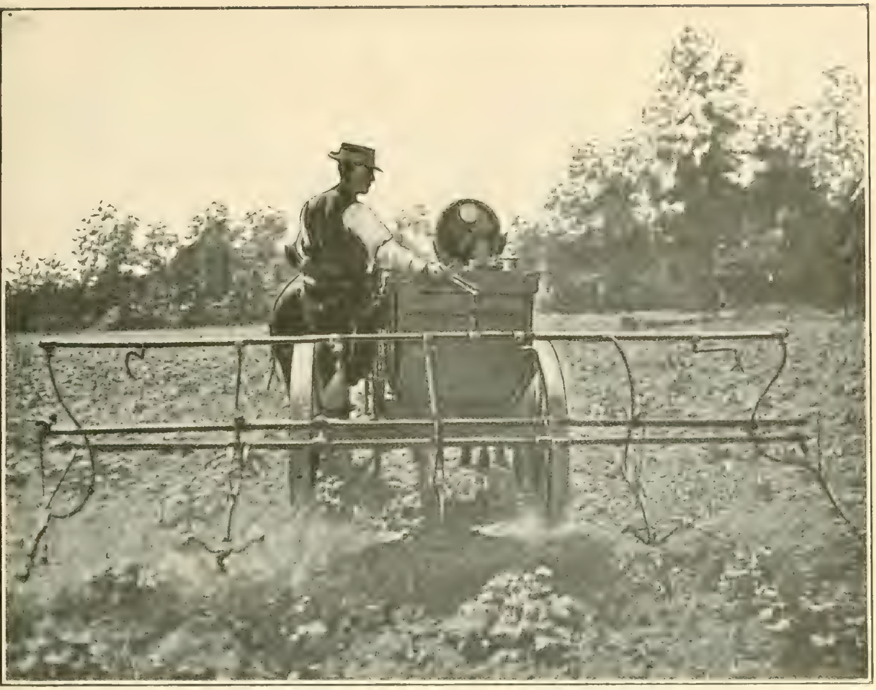


FIG. 217.—Field sprayer, with modifications, adapted for potato spraying, by L. C. Corbett, operating at the Virginia Truck Experiment Station, Norfolk, Va.

beetle (*Epitrix parvula*) is not uncommonly found on the vines in sections where tobacco is also grown, and other species do similar injury in other sections. All of these species are, however, essentially the same in habits and life history, and the same remedies apply to all. Unfortunately, the complete life cycle of these little insects has never been carefully determined, so that only a general outline can be given.

The potato flea-beetle * is the most destructive. It is only one-sixteenth inch long, jet black, except the yellowish antennæ and legs, and there is a deep groove across the base of the thorax

a *b*

FIG. 218.—*a*, potato flea-beetle; *b*, egg-plant flea-beetle, both greatly enlarged. (After Chittenden, U. S. Dept. Agr.)

(Fig. 218, *a*). It seems to occur throughout the United States, but is more commonly injurious in the North. Eggplant and tobacco, as well as numerous garden vegetables are similarly injured. This species has commonly been called the cucumber flea-beetle from its specific name, but it is evidently a misnomer, as it is much more abundant upon the potato and related plants.

During the winter the beetles hibernate under leaves, rubbish, etc., and in the spring come forth and lay their eggs upon the roots of some of our common weeds of the Nightshade family, such as the horse-nettle, Jamestown-weed, Desmodium, etc., in May and June. The larvæ mine in the roots of these plants and transform to pupæ in small earthen cells among the roots,

* *Epitrix cucumeris* Harris.

from which the beetles come forth to attack the foliage of the crops mentioned. There are at least two and probably three generations a year, but the life history of the species has not been carefully studied. The larvæ are minute, thread-like, white worms.

Occasionally the larvæ mine into the tubers, doing considerable damage and causing "pimply" potatoes. Such injury was quite common in New York, in 1894, and in Colorado in 1903.

The principal injury by the beetles is done to the young foliage just after it is up in the spring, when then swarm upon the plants and thoroughly riddle the leaves, a badly eaten leaf appearing as if it had been hit by a charge of fine bird-shot. The complete life history of the species has not been definitely determined, but the injury by the adults is rarely troublesome except when the plants are young, and the larval injury to the tubers occurs later in the season.

The Eggplant Flea-beetle * so nearly resembles the previous species that it will not be distinguished from it but by the entomologist. It is slightly larger, however, with the wing-covers more hairy, and the groove at the base of the thorax is not so distinct. It has much the same food-plants, but is particularly abundant on eggplant, and is more commonly injurious in the South, below the Ohio and Potomac rivers.

The Tobacco Flea-beetle † has been previously discussed (page 222), but should be mentioned, as it is commonly injurious to potato, tomato, and eggplant throughout the South, as well as to tobacco, and occasionally to corn and other plants.

Control.—It has been found that Bordeaux mixture acts as an excellent repellant against these little beetles, and that plants well covered with it are not seriously injured. Inasmuch as it is always advisable to spray potatoes as soon as they are a few inches high for fungous diseases and for the Colorado potato beetle, by applying the spray as soon as possible after the plants are up they will be protected. Both potatoes and tomatoes should be sprayed with Bordeaux mixture and arsenate of lead

* *Epitrix fuscula* Cr. † *Epitrix parvula* Fab.

or Paris green as soon as they are a few inches high. The spray should be applied liberally so as to give the plants a distinct coating of the mixture. Tomatoes are particularly susceptible to injury and might be dipped in arsenate of lead when planting, using 1 pound to 10 gallons of water. The destruction of the weeds upon which the larvæ commonly develop is obviously important in preventing their multiplication.

Where injury by the larvæ is done to the tubers, it is recommended that they be dug as soon as possible, and be left exposed to the sun for a few hours after digging so as to harden the skin, before being stored. If damage continues in storage, the tubers may be fumigated with carbon bisulfide, as recommended for grain insects (page 57).

Potato-scab and Insects

That certain forms of what is commonly termed "potato-scab" are due to the work of insects has frequently been shown. In 1895 Professor A.D. Hopkins,* of the West Virginia Agricultural Experiment Station, reported some very careful original investigations upon two species of gnats, *Epidapus scabies* Hopk. and *Sciara* sp., the larvæ of which had been conclusively shown to cause a "scab" upon the tubers by boring into them. The larvæ or maggots of the Potato-scab Gnat are about one-sixth of an inch long, and are the young of a wingless gnat shown, very greatly enlarged, in Fig 219. The females deposit their eggs on the potatoes in storage from autumn to spring, and the maggots hatching from them enter old scab spots or injured places. Under favorable conditions a generation may be developed in twenty to twenty-five days. Later in the spring the eggs are deposited in manure or other decomposing material, on seed potatoes or on growing tubers to which they may be carried on seed potatoes. When they become well established in a potato, it is soon destroyed if they are not overcome by their natural enemies, or unless the soil becomes dry, when they soon disappear. In-

* A. D. Hopkins, Special Bulletin 2 (Vol. IV, No. 3) W. Va. Agr. Exp. Sta., p. 97.

fested places look very much like the ordinary scab produced by the scab fungus and may be readily mistaken for it. Such injury was quite general and serious in West Virginia in 1891 and 1892. Dr. Hopkins found that "they breed in and are especially common in barnyard-manure," that "excessive moisture in the soil has been observed to be the most favorable condition for their development," and that "soaking the seed-potatoes in a solution of corrosive sublimate previous to planting" will kill all the eggs and young larvæ, as it will also destroy the spores of the potato-scab fungus.

Professor H. Garman * has also recorded the injuries of several species of millipedes, or "thousand-legged worms," *Cambala*

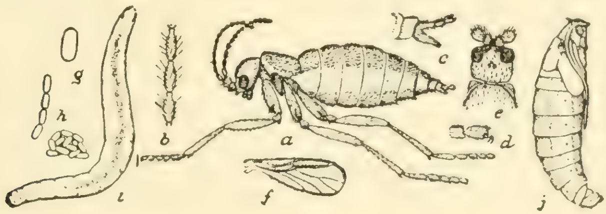


FIG. 219.—Potato scab-gnat (*Epidapus scabei* Hopk.): *a*, fly; *i*, larva; *g*, egg; *h*, egg mass—much enlarged. (After Hopkins.)

annulata and *Parajulus impressus*, as causing a scab by gnawing into the surface of the tubers. Though both of these observations are unquestionably true, such injury has not occurred in other parts of the country, and it is improbable that any large portion of potato-scab is due to these insects. Potato-scab is a fungous disease, which, as already noted, may be destroyed by soaking the seed-potatoes in a solution of corrosive sublimate.

Blister-beetles †

Long before we had made the acquaintance of the Colorado potato-beetle, several species of blister-beetles frequently brought

* H. Garman, Bulletin 61, Ky. Agr. Exp. Sta., p. 18.
† Family *Meloidæ*.

themselves into notice by their injuries, and, therefore are now known as the "old-fashioned potato-bugs." The name of "blister-beetles" has been bestowed upon them because of the blistering effect which they have upon the skin, they being nearly related to the Spanish fly, used for that purpose.

One of the most common of these is the Striped Blister-beetle, which has three yellow stripes upon its wing-covers, while two other common forms are of a slate-black color. Very often when these beetles congregate in numbers they are a great nuisance, not only in the potato-patch, but upon many other plants of the garden or truck-farm.

Unfortunately, they present to the farmer a very peculiar problem, for while the beetles are often exceedingly injurious, the larvæ are even more beneficial, in eating large quantities of grasshoppers' eggs.

Life History.—The life of these insects is unique. The female lays a large number of eggs in a small cavity in the earth, and from these hatch some small, long-legged larvæ, which run about searching for the pod-like masses of grasshoppers' eggs, upon which they feed. As soon as the appetite of one of these little egg-hunters is appeased, he sheds his skin, and now being surrounded by food and no longer needing his long legs for running, in the next stage of his existence his legs become very short and rudimentary, and he remains almost immobile while feeding upon the rest of the eggs.

Control.—Spraying with Paris green or arsenate of lead, as advised for the Colorado potato-beetle will kill the beetles, and where the vines have been regularly sprayed but little trouble will be had with them. Where they suddenly appear in large swarms in gardens or on truck land, they are often destroyed by a line of men and children slowly driving them with branches, as the beetles move but slowly. If a ditch is available it may be oiled, and the beetles destroyed like grasshoppers (page 108), or they may be driven into a windrow of straw, hay, or any inflammable rubbish and burned in it.

Three-lined Leaf-beetle *

Closely related to the Colorado potato-beetle, and very similar to it in habits, is the Three-lined Leaf-beetle. The eggs may be distinguished by the fact that they are usually laid in rows along the midrib on the under side of the leaf, while those of the potato-beetle are laid indiscriminately in bunches. The larvæ, however, may be readily distinguished from all other insects attacking the potato by being covered with a disgusting mass of their own excrement.

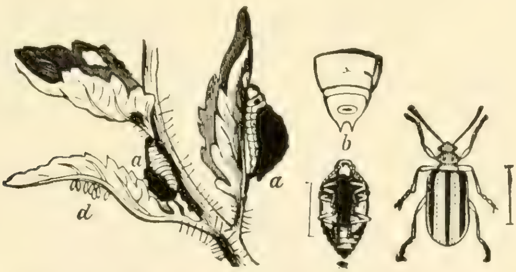


FIG. 220. Three-lined leaf-beetle (*Lema trilineata* Oliv.); *a*, larva; *b*, pupa; *d*, eggs; beetle at right. (After Riley.)

There are two broods during the season, the larvæ of the first appearing in June, and that of the second in August; but the beetles of the second brood do not emerge until the following spring. In other respects the life history is practically the same as that of the Colorado potato-beetle. The beetle is of a pale yellow color, with three black stripes on its back, and in a general way resembles the common striped cucumber-beetle (*Diabrotica vittata* Fab.), though it is somewhat larger and the thorax is decidedly constricted.

In case it becomes necessary to destroy the blister-beetles, both they and the three-lined leaf-beetle may be readily disposed of by applying Paris green or other arsenite as advised for the Colorado potato-beetle.

* *Lema trilineata* Oliv. Family *Chrysomelidæ*.

Tomato Worms

The large green horn-worms which attack the foliage of the tomato are the same as those previously described which attack tobacco (see page 228). Usually they are not so numerous but that they may be readily controlled by handpicking, but if necessary the same remedial measures may used as advised for them on tobacco.

The Tomato Fruitworm

The worms which commonly bore into the green and ripening tomatoes are the same as the tobacco budworm and the cotton bollworm (see pages 234 and 254), under which names their habits and life histories have been fully described.

Obviously tomatoes should not be planted on land which has been in corn or cotton infested by this insect the previous year, unless it has been given thorough winter plowing and harrowing.

It has seemed to the writer that trap rows of sweet corn might be used for protecting tomatoes as they are used with cotton, but no experiments seem to have been conducted which show the practicability of the method. As the young caterpillars feed a little on the foliage before boring into the fruit, a thorough spraying with arsenate of lead, 3 pounds to 50 gallons, will undoubtedly protect the tomatoes if applied as soon as the eggs are laid, and with one or two later applications at intervals of ten days, the exact time depending upon the latitude and season, as indicated by the life history (see page 181).

CHAPTER XVI

INSECTS INJURIOUS TO BEANS AND PEAS *

The Pea-weevil †

THE common Pea-weevil occurs in almost all parts of the world where peas are grown, and is the usual cause of "buggy" peas. It was the cause of the abandonment of pea growing in the central Atlantic States as early as the middle of the eighteenth century. It has usually been regarded as a native of North America, having

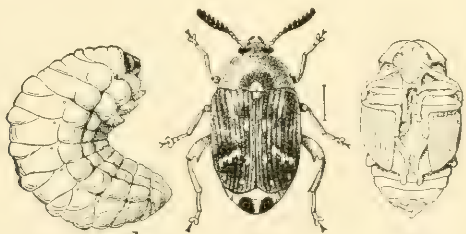


FIG. 221.—The pea-weevil (*Bruchus pisorum* L.): *a*, adult beetle; *b*, larva; *c*, pupa—all enlarged. (From Chittenden, U. S. Dept. Agr.)

been introduced into Europe. It does but comparatively little damage in more northern latitudes and for this reason seedsmen secure their seed peas from Canada and northern Michigan and Wisconsin.

The weevil is about one-fifth inch long and about one-half that width, being the largest of the pea- and bean-feeding weevils in this country. "Its ground color is black, but it is thickly covered with brown pubescence, variegated with black and white

* See F. H. Chittenden, Insects Injurious to Beans and Peas, Yearbook U. S. Dept. Agr. for 1898, p. 233.

† *Bruchus pisorum* Linn. Family *Bruchidæ*.

markings as shown in Fig. 221. The sides of the thorax are notched or toothed, and the abdomen, which projects beyond the wing-covers, is coated with whitish pubescence and marked by two black spots. The hind thighs are thickened and each bears two prominent teeth."

Life History.—The winter is passed in the adult stage, the weevils making their appearance in the fields when the peas are in blossom. The eggs are laid singly upon the surface of the pods, attached by a sticky fluid which becomes white when dry. The egg is about one-twentieth of an inch long by one-third that width, of a yellow color, as shown in Fig. 222.

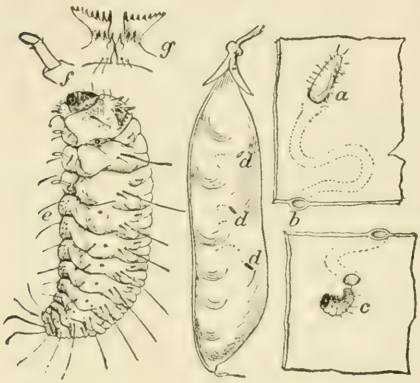


Fig. 222.—The pea-weevil: *a*, egg on pod; *b*, cross-section of opening of larval mine; *c*, young larva and opening on inside of pod by which it has entered—enlarged *d*, *d*, *d*, eggs on pod, slightly enlarged; *f*, leg of larva; *g*, prothoracic spurious processes—more enlarged. (After Chittenden, U. S. Dept Agr.)

Upon hatching, the young larva bores through the pod and into the seed. In this stage the larva has some very small false legs and two plates and six strong spines on the thorax, which aid it in getting through the pod. Upon entering the seed the skin is shed and these legs, plates and spines are lost. The larva feeds upon the seed, growing rapidly. When full grown it appears as at *b*, Fig. 221. It resembles a maggot in general appearance, being white, except the small mouth-parts, which are brown; is fleshy, nearly cylindrical and strongly wrinkled, with three pairs of very short stubby legs. It is about one-fourth an inch long and half as broad. Before its final molt the larva eats a round hole in the pea, leaving but a thin membrane as a covering. It then lines the inside of the pea with a glue-like substance, and within this cell transforms to the pupa.

The pupa is white, showing the notches at the sides of the thorax, but otherwise is not dissimilar from many weevil pupæ. The length of the pupal stage varies from nine to seventeen or more days. In more southern latitudes a large part of the beetles leave the seed in August, but in the North they all remain in the seed over winter, and are planted with the seed. There is but one generation a year and this species does not breed in dry peas.

Injury.—Dr. James Fletcher has stated that this pest is now doing over $1,000,000 damage in Ontario alone annually, and that the growing of peas has been abandoned in considerable areas of that province. In large peas about one-sixth of the food content is destroyed, while in smaller varieties fully one-half. Not only this, but in eating canned green peas one frequently devours several small larvæ in each mouthful, unawares, as but a small dark speck indicates their presence in the green pea. In the dry seed the holes made by the larvæ can be seen. But 12 to 18 per cent of infested seed will produce plants, which are later in developing and do not yield as well as those unaffected.

Enemies.—The Baltimore oriole has been recorded as feeding on the grubs by splitting open the pods, and the crow blackbird is said to devour many of the beetles in the spring. Practically no parasites or predaceous insects are known to prey upon it, so that it has every opportunity for doing serious injury.

Control.—Holding over Seed.—One of the best means of destroying the weevils where but a few peas are concerned and circumstances will permit, is to simply hold them over for a season, stored in a tight sack or box, before planting. As the weevils will not breed in the dried peas they die in the sack and are thus caught. Peas should always be bagged up and sacks tied immediately after threshing.

Late Planting.—Comparative immunity from injury is claimed by some growers for late-planted peas. Dr. F. H. Chittenden is inclined to the belief that in some localities, such as Washington, D.C., where two crops can be grown in a year, that late planting is all necessary to secure sound seed stock.

Treating with Kerosene.—The Canadians have found that

kerosene may be used to destroy the weevils. Dr. Fletcher states: "A remedy which has been used by many farmers with satisfaction is to drench the seed with coal oil, using about a half a gallon to the barrel, or five bushels of peas. While applying the coal oil (kerosene) the seed should be placed on the floor, where it can be shoveled over constantly to insure the treatment of all the grain."

Scalding Seed.—" When peas are found to contain live weevils at the time of sowing, these may be destroyed by simply pouring them into a pot of scalding water. The water should be drained off at once or the seed cooled by turning in cold water."—Fletcher.

Heat.—Dr. Chittenden states that it has been found that a temperature of 145° F. will kill the weevils in the seed without injury to the germinating property of the seed.

Fumigation.—This is undoubtedly the best means of destroying the weevils, and is now coming into general use. Dr. Fletcher, who has made the most thorough studies of practical methods for controlling this pest, states: " Fumigation with bisulfide of carbon is a sure remedy. When properly done, either in specially constructed buildings known as ' bug-houses ' or in any tight bin, every weevil is surely killed if the seed containing them is fumigated for forty-eight hours with this chemical, using 1 pound by weight to every 100 bushels of seed, or, in smaller quan ities, 1 ounce to every 100 pounds. For the treatment of small quantities of seed, particularly by farmers, I have found that an ordinary coal-oil barrel is very convenient. This will hold about 5 bushels, or 300 pounds of seed, which may be treated with 3 ounces of bisulfide of carbon. Care must be taken to close up the top tightly. This is best done with a cap made specially for the purpose, but fine sacks laid smoothly on the top, over which boards are placed with a weight on them, will answer. Fumigation with bisulfide of carbon is, I believe, the remedy most to be relied upon in this campaign. It is perfectly effective, is now regularly used by the large seed merchants, and in future will be much more generally used."

(For directions for use of bisulfide of carbon and caution concerning it, see page 57.)

The Common Bean-weevil *

Throughout the United States the common Bean-weevil is the principal enemy of the bean. The small, white, footless grubs feed within the beans, both in the field and in storage, and transform to the common brown-gray weevils which infest white beans. In the South its attacks are so serious that it is almost impossible to secure a crop uninfested, so that most of the beans both for seed and consumption come from the North. Not until 1870 did injury by this insect attract attention in the United States, but now it occurs throughout our borders and is practically cosmopol-

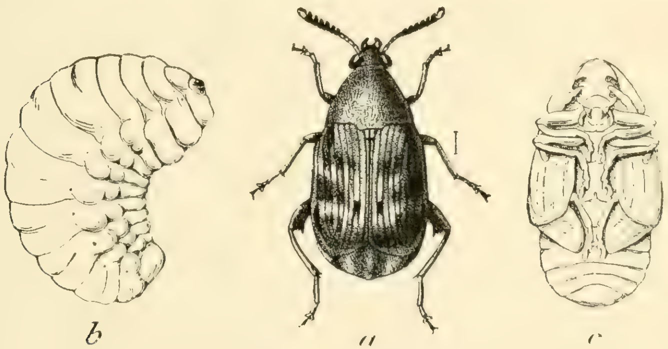


Fig. 223.—The common bean-weevil (*Bruchus obtectus* Say): *a*, beetle; *b*, larva; *c*, pupa—all greatly enlarged. (After Chittenden, U. S. D. Agr.)

itan in its distribution. It is probably a native of Central or South America.

The adult weevil is about one-eighth of an inch long and is covered with a fine brown-gray or olive pubescence, giving it that color, while the wing-covers are mottled as shown in Fig. 223, *a*. It may be distinguished from the pea-weevil by its longer thorax and by the two small teeth next to the large tooth at the tip of the thighs.

Life History.—In the field the eggs are laid upon or are inserted in the bean-pod through holes made by the female or such open-

* *Bruchus obtectus* Say. Family *Bruchidæ*.

ings as are caused by its drying and splitting (Fig. 224, *b*, *c*). In shelled beans the eggs are placed loosely among them or in the exit holes of the beetles. The young larva hatching from the egg has long, slender legs, but with the first molt these are lost and when full grown it is a fat grub as shown in Fig. 223, *b*. The pupal stage is passed in an oval cell made by the larva within the bean. Experiments have shown that the eggs hatch in from five days in the hottest to twenty days in cooler weather; the larval stage requires eleven to forty-two days, and the pupal stage five to eigh-

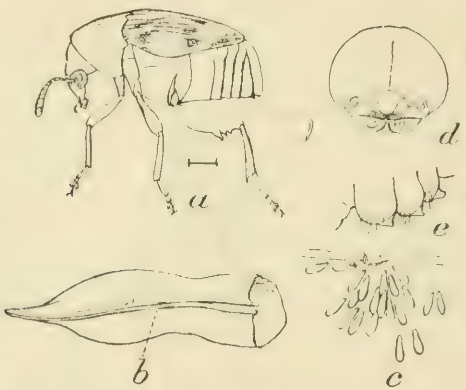


Fig. 224.—The bean-weevil; *a*, side view of beetle; *b*, section of bean pod showing slit for deposition of egg; *c*, part of inside of pod showing egg-mass inserted through slit—all enlarged. (After Riley and Chittenden, U. S. Dept. Agr.)

teen days. Thus the whole life cycle will extend over a period of from twenty-one to eighty days, depending upon the season and locality. Probably about six generations occur annually in the District of Columbia, and a less number further north.

"Unlike the pea-weevil, a large number of individuals will develop in a bean, as many as twenty-eight having beenf ound within a single seed. It will thus be readily seen that the first outdoor generation or any single indoor generation is capable of exhausting seed and completely ruining it for food or planting or any other practical purpose, except perhaps as hog feed."

"The beetles begin to issue from beans in the field in a climate

like that of the District of Columbia . . . as early as October, when in the natural course of events the eggs for a new brood would be deposited in such pods as had cracked open, so as to expose the seeds within."

"Weevilly" seed should never be planted, as but a small per cent of it will germinate and the vitality of that germinating is deficient. Professor Popenoe showed in experiments at Manhattan, Kan., that only 50 per cent of the infested seed used germinated, that only 30 per cent could ha e grown further, and that even these would have produced plants of little vigor or productiveness. (Quotations and acts from Chittenden, l.c.)

Remedies.—No methods are known of preventing injury in the field, and all remedial measures must be applied to the insects in the stored seed. As this pecies breeds in the stored seed, it is useless to hold it over as for the pea-weevil, and the quicker infested seed is treated the better. Either heat, or better, fumigation, as described for the pea-weevil, should be used. When ready to plant, seed should be thrown lightly into water, when that badly infested will float and can be separated and destroyed.

Other Bean-weevils

*The Cow-pea weevil.**—This species may be readily recognized by the two large, raised white lobes at the base of the thorax and the strongly pectinate antennæ of the male as shown in Fig. 225, *a*. The cow-pea is the favorite food-plant of this and the following species, but peas and various sorts of beans are also attacked. This species is a southern form, but seems to be spreading, incident to the more wide-

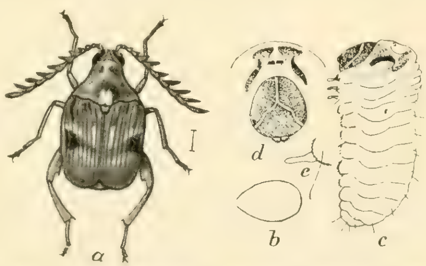


FIG. 225.—The cow-pea weevil (*Bruchus chinensis* L.): *a*, adult male; *b*, egg; *c*, young larva; *d*, front view of head of same; *e*, thoracic leg of same;—*a*, much enlarged; *b*, *e*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

* *Bruchus chinensis* Linn.

spread growth of the cow pea. Like the common bean weevil it is practically cosmopolitan in its distribution, but is most injurious

FIG. 226.—The four-spotted bean-weevil: *a*, beetle; *b*, larva; *c*, pupa—all enlarged. (After Chittenden, U. S. Dept. Agr.)

in tropical regions. The life history and remedial measures are practically the same as for the common bean-weevil.

*The Four-Spotted Bean weevil.** The wing covers of this species

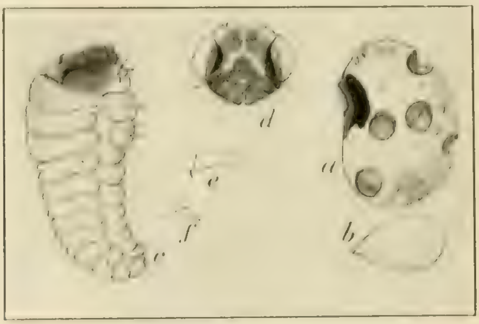


FIG. 227.—The four-spotted bean-weevil: *a*, cow-pea showing holes made by weevils in their escape from seed, also eggs deposited on surface; *b*, egg; *c*, young larva; *d*, head of same; *e*, prothoracic leg; *f*, spine above spiracle of first abdominal segment—*a*, twice natural size; *b*, *f*, greatly enlarged. (After Chittenden, U. S. Dept. Agr.)

are covered with gray and white pubescence and four darker spots from which the species is named. It is more slender than the preceding species and the antennæ of the male are not pectinate.

* *Bruchus quadrimaculatus* Fab.

The markings are quite variable, but the most common form is that shown in Fig. 226. This is an exotic species occurring from Mexico to Brazil and in the Mediterranean countries. In 1885 it was found at the Atlanta Cotton Exposition in black-eyed beans from Texas, and has since become acclimated as far north as Iowa. It seems to breed more readily in fresh and slightly moist seed and, like the preceding species, its work in stored beans seems to soon cause decomposition and a consequent rise of temperature. The life history and remedial measures are similar to those of the bean-weevil.

The European Bean-weevil * was imported into New York and New Jersey in 1870, at the Columbian Exposition at Chicago in 1893, and has been observed at College Station, Texas, but does not seem to have become established in this country. It closely resembles the pea-weevil in appearance and life history.

The Bean Leaf-beetle †

Small yellowish or reddish beetles, marked with black, as shown in Fig. 228, and from one-seventh to one-fifth inch long, are often found eating the foliage of beans, and are commonly known as Bean Leaf-beetles. The species occurs throughout the United States east of the Rockies, but has been chiefly injurious in the Middle and Southern States. Besides beans, the beetles feed upon cow-peas and various native plants such as beggar-weed or tickseed, tick trefoil (*Meibomia*), bush-clover (*Lespedeza*), and hog-peanut (*Falcata*). They usually become quite numerous before they are observed, for during most of the day they rest or feed on the under sides of the leaves. They are sluggish and seldom fly, and when disturbed often drop to the ground, though they soon crawl back to the plant. Large round holes are eaten in the foliage until finally nothing but the veins and midrib of a leaf is left, the manner of defoliation being quite characteristic of this species. Low-growing and dwarf varieties are worse injured, as pole beans put out new leaves after the injury has stopped.

* *Bruchus rufimanus* Boh.

† *Ceratoma trifurcata* Forst. Family *Chrysomelidæ*.

Life History.—The adult beetles hibernate in or near the bean-fields and emerge from April to June according to the latitude. Minute orange-colored eggs are laid near the stem of the plant, just below the surface of the soil, in clusters of six to ten or more, and hatch in from five to eight days. The young larvæ feed upon the stem and roots, becoming full grown in six or seven weeks. When grown the larva is about three-tenths an inch long, about one-eighth as wide, cylindrical, milk-white in color, with dark head and anal segment, as shown enlarged six times in Fig.

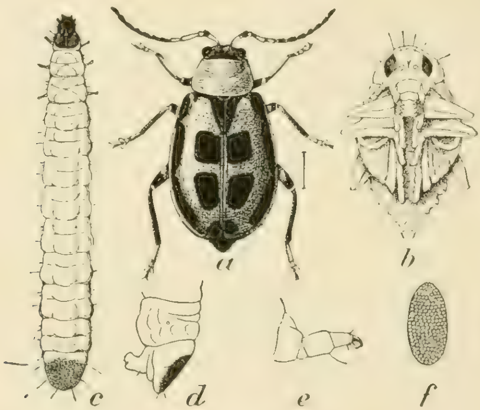


FIG. 228.—The bean leaf-beetle (*Ceratoma trifurcata* Forst.): *a*, adult beetle; *b*, pupa; *c*, larva; *d*, side view anal segment of larva; *e*, leg of same; *f*, egg—*a*, *b*, *c*, enlarged about six times; *d*, *e*, *f*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

228. The pupa (Fig. 228, *b*) is pure white, and from it the beetle emerges in five to eight days. Thus, in the District of Columbia, the whole life cycle requires six to nine weeks, depending upon heat and moisture. In the North there is probably but one generation a year; in Maryland and Virginia one generation develops in July and another in September; while in the Gulf States there are probably three generations, as beetles are numerous in October.

Remedies.—Spraying with arsenical poisons as for the bean ladybird (page 316) is the most effectual means of controlling the pest when abundant, but they should be applied early to avoid

the poison on beans to be eaten green. Owing to the sluggishness of the beetles they may be handpicked in small gardens. Clean culture and careful weeding of native food-plants near cultivated crops such as tick-trefoil and bush-clover, are most important.

The Bean Ladybird *

The Bean Ladybird is the most serious enemy of beans in Colorado, New Mexico, Arizona, and Western Kansas, whence it migrated from Mexico. It is an interesting insect in that only two other native species of this family of beetles (*Coccinellidæ*) feed upon vegetation, the normal food of the family being plant-lice, scale insects, and soft-bodied larvæ.

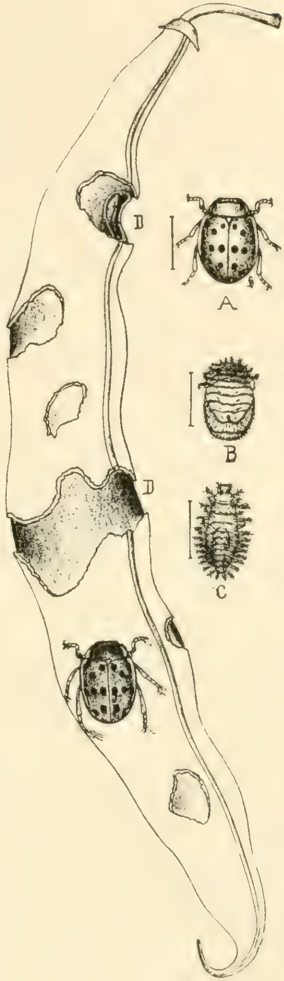


Fig. 229.—The bean ladybird (*Epilachna varivestis* Muls.): *a*, adult beetle; *b*, pupa; *c*, larva; *d*, bean pod showing injury. (After Gillette, Colo. Agr. Exp. Sta.)

Professor C. P. Gillette † describes it as follows:

"The beetle (Fig. 229, *A*) is oval in outline, nearly one-third an inch in length by one-fifth an inch in breadth, of a light yellow to a yellowish-brown color and has eight small black spots on each wing-cover. The mature larva is about the same length as the beetle, is of light yellow color and is covered with stout branched spines that are black at their tips, a larva being shown at *C*, Fig. 229. The larva when fully grown fastens the posterior end of its body to the under side of a leaf and then in a

* *Epilachna varivestis* Muls. Family *Coccinellidæ*.
† Bulletin 19, Colo. Agr. Exp. Sta., p. 25.

few days sheds its outer skin containing the spines and changes to the pupa state (Fig. 229, *B*). From these pupæ the beetles appear a few days later. They live over winter, and appear about as soon as the beans are up in the garden or field and begin to feed upon the leaves, on the under side of which they deposit their yellowish-brown eggs in large clusters after the manner of the 'Colorado potato beetle.' The spiny little larvæ that hatch from these eggs remain on the under side of the leaves, which they skeletonize in feeding. The beetles eat through the veins of the leaves and do not skeletonize them. They also eat into and destroy the green pods, as shown in Fig. 229, *D*. There is also one brood of this insect in a season.

Control.—Paris green dusted upon the plants diluted with 100 parts of air-slaked lime or flour is recommended, or it may be applied with Bordeaux mixture, 1 pound to 200 gallons, but much care must be used not to burn the foliage, which seems to be very susceptible to the arsenic. Arsenate of lead would probably obviate this. In spraying, an underspray nozzle must be used to reach under the leaves. Dilute kerosene emulsion will kill the larvæ, but must also be used with caution to avoid injury to the plant. Whaleoil soap might be as effective and less injurious to the plant. Upon small gardens handpicking of the adult beetles as soon as they appear in the spring will probably be the surest means of combating them. Cleaning up the old patch and plowing it under will doubtless aid in preventing successful hibernation.

Blister-beetles.

Several species of elongate, grayish, black or bright green blister-beetles feed in large numbers upon bean foliage. The general life history, habits, and remedies have been already described. (See pages 107, 301.)

*The Ash-gray Blister-beetle.**—This is the most common species affecting beans in the East and westward to Kansas and Nebraska. The beetle is a uniform ash-gray color and of the form shown in

* *Macrobasis unicolor* Kby.

Fig. 230. The beetles attack this and other legumes in immense swarms, riddling the forest in a few days if not checked, and appear from the middle of June to the middle of July.

*Nuttall's Blister-beetle.**—This species occurs from the Mississippi west to the Rockies, through the region of the Missouri Valley, and north to the Northwest Territories, where it seems to be particularly destructive to beams, though affecting many garden vegetables. The life history is not known, but is probably

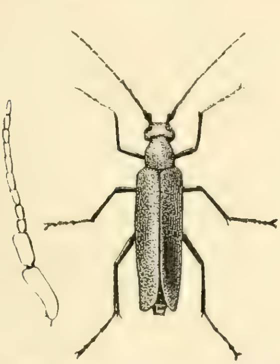


FIG. 230—The ash-gray blister-beetle (*Macrobasis unicolor* Kby.): female beetle at right, twice natural size: male antenna at left, greatly enlarged. (After Chittenden, U. S. Dept. Agr.)

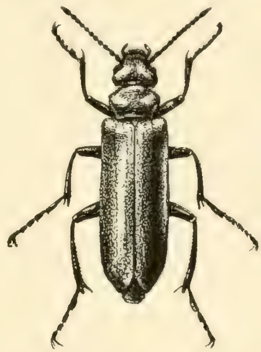


FIG. 231.—Nuttall's blister-beetle (*Cantharis nuttalli*) Say: female beetle, enlarged one-third. (After Chtttenden, U. S. Dept. Agr.)

similar to that of other species, as the beetles appear about July 1st. in years following severe outbreaks of grasshoppers. Owing to the rapidity with which this species works and the large numbers, poisons will be of little avail and mechanical measures must be employed for their destruction.

Control.—See page 302.

The Bean-aphis †

"Crowded together in clusters upon the top of the stalks and under side of the leaves of the English bean, the puppy dahlia, and several other plants, a small black plant-louse with

* *Cantharis nuttalli* Say.
† *Aphis rumicis* Linn. Family *Aphididæ*.

pale shanks, the pupæ with a row of mealy white spots along each side of the back."—Fitch.

This is an old European pest of the bean, where it is known as the black dolphin, collier, and black fly, and has sometimes caused the entire destruction of a crop. In the United States it probably occurs wherever beans are grown, having been reported from New York, Illinois, Iowa, Minnesota and Colorado. The species is probably best known as affecting various species of dock, upon the leaves of which it occurs commonly in large numbers. Shepherd's purse, pigweed, the "burning bush" (*Euonymus europoeus* and *atropurpurus*), and the snowball bush are also commonly infested.

Life History.—The life history was first described most interestingly by Dr. Fitch in his 13th Report * and has since been confirmed by Osborne and Sirrine.† The eggs are laid in the fall around the buds of the wahoo or "burning bush" (*Euonymus atropurpurus*), and possibly upon the snowball. The first generation or two multiply upon these plants and then spread to common weeds such as shepherd's purse, pigweed, dock, etc. during the latter part of May and early June, from which they again migrate to beans when that crop is available. During the summer the aphides multiply upon these food-plants viviparously, i.e., by giving birth to live young, all being females, as is the rule with aphides; but about the middle of September, in Iowa, winged males and females migrate back to the wahoo.

Description.—The wingless females are about one-tenth an inch long, pear-shaped, sooty black, frequently marked with pruinose whitish dots along each side of the back. The antennæ are about half the length of the body, yellowish-white, except toward the tips and the two basal segments, which are black. Honey tubes short, scarcely half as long as from their bases to tip of abdomen. Tail half as long as the honey tubes.

The winged females are glossy black, one-twelfth an inch

* Fitch, 13th Report on the Noxious, Beneficial and other Insects of the State of New York, Trans. N. Y. State Agr. Soc., 1869, p. 495.

† Osborn and Sirrine, Bulletin 23, Iowa Agr. Exp. Sta., p. 901, 1894.

long to the tip of the abdomen and twice that length to the tip of the closed wings. The abdomen lacks the white spots of the wingless females and pupæ. Legs are black, except shanks, which are whitish with dark tips. Otherwise the winged form resembles quite closely the wingless form. The black color and white spots on the abdomen of the wingless females and pupæ will readily distinguish the species from other aphides on beans.

Control.—Spraying with dilute kerosene emulsion has proven the best means of combating the pest according to Osborn and Sirrine, diluting the stock solution fifteen times, or so the spraying mixture will contain about 5 per cent of kerosene. It seems that the foliage of the bean is quite susceptible to injury from any free kerosene, and probably whaleoil soap 1 pound to 5 or 6 gallons, would prove safer and equally efficient. As it is frequently necessary to spray beans with Bordeaux mixture or other fungicides for fungous diseases, the whaleoil soap might be readily sprayed at the same time.

The Gray Hair-streak Butterfly *

The caterpillars of the Gray Hair-streak Butterfly have been noticed injuring beans, peas and cow-peas, for a number of years throughout the United States, but the injury is usually local and not often serious. The caterpillar is about one-half an inch long, decidedly flattened, somewhat oval, bright green, with head retracted in the thorax, and covered with short hairs, which give it a velvety appearance. The adult butterfly is a handsome bluish-black butterfly with red anal spots as shown in Fig. 177. The caterpillar has been a serious enemy of hops, and in the South attacks cotton squares, being termed the cotton square-borer, but the pods of legumes seem to be the preferred food. Where injury recurs, thorough spraying with Paris green or arsenate of lead as the pods are forming will doubtless hold the larvæ in check, as the eggs are laid upon the foliage and the young larvæ

* *Uranotes melinus* Hubn. Family *Lycænidæ*.

feed somewhat upon it and will secure enough of the surface of the pods in entering to effectively poison them if the pods are well coated.*

The Seed-corn Maggot †

This insect has been termed the Seed-corn Maggot on account of its frequent injuries to early seed-corn, but in recent years it has often seriously injured the seeds of beans and peas, on account of which it has been termed the "bean-fly," while cabbage,

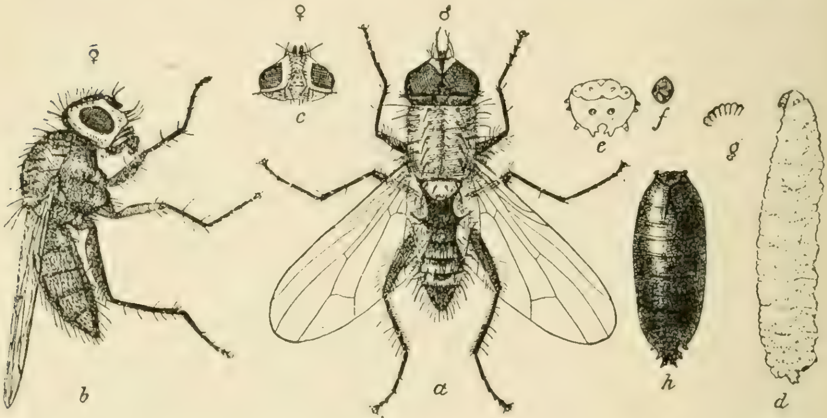


FIG. 232.—Seed-corn maggot (*Pegomya fusciceps*): *a*, male fly, dorsal view; *b*, female, lateral view; *c*, head of female from above; *d*, larva, from side; *e*, anal segment of larva; *f*, anal spiracles; *g*, cephalic spiracles; *h*, puparium—all much enlarged. (After Chittenden, U. S. Dept. Agr.)

turnip, radish, onions, beets and seed potatoes are among its other food-plants.

The species is of European origin, and was first noted in this country by Dr. Asa Fitch in 1856. Since then it has become distributed throughout the United States from Minnesota to Texas and eastward.

The adult flies closely resemble the root-maggots affecting

* See "Insect Life," Vol. VII, p. 351. Chittenden, Bulletin 33, Div. Ent., U. S. Dept. Agr., p. 101; Sanderson, Farmers' Bulletin, U. S. Dept. Agr., 223, p. 17, and Bulletin 57, Bureau Entomology, p. 40.

† *Pegomya fusciceps* Zett. Family *Anthomyidæ*.

the cabbage and onion and are about one-fifth an inch long. The male may be distinguished from nearly related species by a row of nearly equal, short bristles on the inner side of the hind tibiæ or shanks.

The life history of the species has not been carefully observed, but is probably similar to that of other root-maggots. The flies deposit their eggs either upon the young seedling just as it appears above ground, or probably more often on the seed itself. Injury is called to attention by the seed failing to germinate, which, when examined, is found to contain one or more small white maggots, which have destroyed the germ or the young seedling. Thus in 1895, large areas of beans were destroyed in Minnesota.*

The maggots are about one-fourth an inch long, slightly smaller than the onion-maggot, from which they may be distinguished by the tubercles of the anal segment.

Control.—It has been noted that injury often occurs where stable manure has been turned under, and it may be possible that the flies are attracted to it to oviposit or that they are attracted by decaying seed. In preventing attacks of root-maggots it would seem advisable to apply stable manure the previous fall so that it may become well rotted and incorporated into the soil before seeding. Rolling the seed-bed after planting might also be of value in preventing the access of the flies to the seed.

Applications of commercial fertilizers which will ensure a quick growth of the seedling are advisable. The use of carbolic acid emulsion and sand and kerosene upon the surface of the seed-bed after planting and as the seedlings are appearing, as advised for the cabbage root-maggot (see page 352), will also be of value. Inasmuch as the injury is sporadic and affects the seed before it can be readily detected, reliance must be placed chiefly upon general cultural methods as outlined above and others which

* See Lugger, Bulletin 43, Minn. Agr. Exp. Sta., p. 207 (1st Rept. Minn. State Entomologist.) See Circular 63, and Bulletin 33, p. 84, Bureau of Entomology, U. S. Dept. Agr.

a better knowledge of the life history of the pest will undoubtedly suggest.

The Pea-aphis *

Large green plant-lice often become so abundant on the foliage and pods of garden-peas as to completely kill the plants. Prior

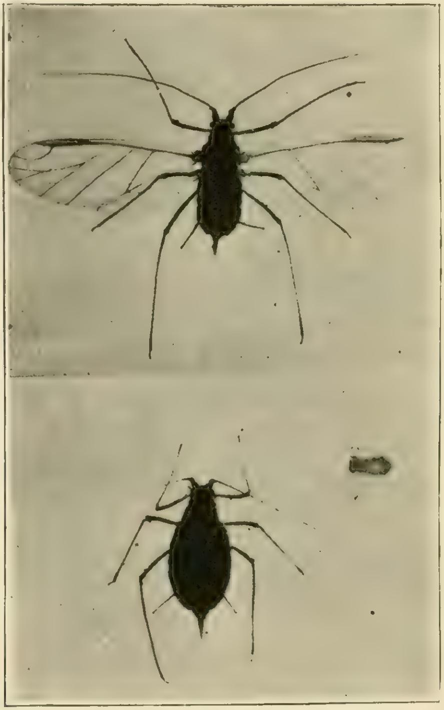


FIG. 233.—The pea-aphis (*Macrosiphum pisi* Kalt): winged and wingless viviparous females and young—enlarged.

to 1899 the pea-aphis had not been a serious pest in this country, but during that and the following season it caused a loss of several million dollars to pea-growers on the Atlantic coast from North

* *Macrosiphum pisi* Kalt. Family *Aphididæ*. See Chittenden, Circular 43, Bureau of Ent., U. S. Dept. Agr.; Sanderson, Bulletin 49, Del. Agr. Exp. Sta.; Folsom, Bulletin 134, Ill. Agr. Exp. Sta.

Carolina to Nova Scotia and as far west as Wisconsin, especially where peas were extensively grown for canning. During 1901 injury was by no means as serious, and has materially decreased since then, though sporadic injury occurs almost every year in some section. General injury occurs only periodically for reasons mentioned below. The pest seems to occur throughout the States east of the 100th meridian and possibly further west. It is an old enemy of peas in England, where it destroyed the crop as long ago as 1810, and it has long been known in Europe as an enemy of peas, clovers, vetches and related plants.

Both wingless and winged aphides occur together throughout the season, the latter predominating whenever food becomes scarce. The winged forms are from one-eighth to one-seventh of an inch long, with wings expanding two-fifths of an inch. The body is a pea-green color, light brownish between the wings and on the head, the eyes are red, and the legs, antennæ and honey tubes are yellowish, tipped with black. The wingless females are similar in size and color, but are much broader across the abdomen, and the honey tubes are somewhat larger. The mouth-parts of the pea-aphis are of the sucking type, and it secures its food by puncturing and sucking up the juices of the plant. The plant is thus injured by the large number of aphides sucking out its juices and causing it to wilt and die.

Life History.—The aphides pass the winter on clover and vetches, and often increase upon clover so as to do it serious injury, as described on page 211. Where peas area vailable the winged females usually migrate to them about the time peas are 6 or 8 inches high, and give birth to live young, which develop into wingless viviparous females. These females, as do those of subsequent broods throughout the summer, give birth to live young, and reproduction goes on at a rapid rate. According to the observations of Mr. R. L. Webster, in central Illinois, an aphid becomes grown about eleven days after it is born, lives about twenty-five days and gives birth to about fifty young, though under favorable conditions over one hundred are frequently born. Sixteen generations have been observed from March 23d to October 4th. Winged

aphides develop as often as the food-plant becomes overcrowded and it is necessary to migrate to avoid starvation.

By midsummer, with the harvesting of the peas, most of the aphides upon them have been destroyed by predaceous and parasitic insects and disease, and they are not observed during late summer unless they have been subsisting on clover throughout the season, when they sometimes destroy the crop in August, as has

Fig. 234.—The pea-aphis on stems of red clover—natural size. (After Folsom.)

been observed in Illinois. In early fall they often become common again on late garden peas, and late in October they migrate to clover. Fewer young are born as the weather gets colder in the fall, and the aphides never become numerous enough to do any injury at that season. Late in October and early November—in the Middle States—as the aphides are migrating to clover, winged males appear, and some of the wingless females developing on clover produce eggs. The winged males are similar in size and color

to the migratory females, though slightly darker, and have three or four dark spots along the sides of the abdomen and a deep brown dash on either side of the back of each abdominal segment. The oval eggs are about one-fiftieth inch long, jet black, and are deposited on the lower leaves or stems of clover, and hatch as it commences to grow in the spring. In central Illinois they were observed to hatch March 23d, and the young became full grown and commenced reproduction on April 5th, living until May 12th. In southern Maryland and further south many of the viviparous females live over winter on the clover and commence to reproduce again in the spring, no eggs having been observed in that latitude, but in central Illinois and northward, the females are probably entirely destroyed by the cold and only the eggs survive.

Natural Enemies.—From 5 to 10 per cent of the aphides are normally destroyed by little wasp-like flies of the genus *Aphidius*, whose larvæ live within the aphides. A number of the more common ladybird-beetles,* syrphus-flies,† and lace-winged flies,‡ which commonly prey upon aphides, destroy large numbers of the pests, but their work comes so late in the season that the peas are seriously injured long before the aphides are checked by them, though they might prevent a reappearance the next year.

The most important enemy of the pea-aphis is a fungous disease (*Empusa aphidis*) which is undoubtedly the principal factor in its natural control. The most probable explanation of the remarkable outbreak of the pea-aphis in 1899 and 1900 seems to be that, due to two exceptionally dry springs, the fungus was unable to develop, as it propagates best in damp weather, and the aphides increased unchecked. Though occasional individual aphides were found killed by the fungus early in the season, not until June 11, 1900, were diseased aphides found in any quantity, but after that so swiftly did the disease destroy them that a week later but few aphides were to be found and almost all were diseased. Probably this fungus usually destroys the aphides on clover before they have become excessively numerous or have migrated to peas.

* Family *Coccinellidæ*. † Family *Syrphidæ*.
‡ Family *Chrysopidæ*. Concerning these predaceous insects, see p. 9.

Control.—Inasmuch as the aphides spread from peas to clover, the latter crop should not be planted near peas when avoidable. In the spring the aphides should be carefully observed on the clover and if they become excessively abundant, the only way to prevent their migration to peas is to plow under the clover deeply and roll the field.

Highly fertilized land in which the moisture is retained by frequent cultivation very often enables a crop to mature in spite of moderate injury. Peas sown broadcast or planted in 8-inch drills have been much more seriously injured than those planted in rows 18 to 30 inches apart and cultivated, and those planted close together afford no opportunity for brushing or cultivating as described below.

Early varieties of peas have practically escaped injury where late varieties have been wholly destroyed, so that it is obvious that only the earliest varieties should be grown where injury is anticipated.

Early in 1900 Professor W. G. Johnson found that when peas were planted in rows that the aphides could be readily knocked from the vines by means of brushing with a branch, and that by following the brushes with cultivators, the aphides would be covered with earth and destroyed, either by suffocation or by the heat of the soil. Where the air temperature is 95° F. the soil will be nearly 120°, and aphides brushed onto it will be actually roasted to death in a few minutes. The cultivation should not be repeated for about three days, as it requires about that time for the destruction of the insects covered with earth, if it is not hot enough to kill them at once. By this method large areas of peas have been saved from destruction, but it was found that where the soil was moist it would form small clods after cultivation and that the aphides would merely crawl out from under them.

To meet this difficulty Professor Johnson devised a pan into which the aphides might be brushed and destroyed. This pan is modelled after the hopper-dozers used in the West for catching grasshoppers, and consists of a long, shallow pan, the width of the distance between the rows and 5 or 6 inches deep. A little water is

placed in the bottom and covered with a film of kerosene. The pan is drawn between the rows while a boy on each side brushes the aphides into it with a branch as shown in Fig. 235. The pans are easily made from galvanized iron and may be operated at small cost.

Though the above methods will destroy quantities of the aphides and thus prevent the destruction of the crop, they do not

FIG. 235.—Showing the structure of pan and use of it with brushes against the pea louse. This field was saved by its use. (After W. G. Johnson.)

dislodge the young aphides in the terminals, and therefore cannot be relied upon to prevent all injury. Practical field tests have shown that this may be done by spraying with whale-oil soap, 1 pound to 6 gallons of water. In small gardens this may be applied by means of bucket or knapsack pumps, and on small acreages with a barrel sprayer with a row-spraying attachment having nozzles arranged so that the vines will be thoroughly covered from each side. The spray must be applied with considerable pressure

so as to force it into the terminals. For large fields a New Jersey grower devised a traction sprayer covering three rows * which applied the material at a cost of $2.50 an acre for labor and materials. To be effective spraying should be commenced as soon as aphides are found generally distributed over the plants. Kerosene emulsion may be used on a small scale, if carefully made, but more or less injury has resulted where it has been used extensively. Probably many of the tobacco preparations now on the market would effectively destroy the aphides and would not injure the vines.

The Pea-moth †

The Pea-moth is an old pest in Europe, whence it was imported into Canada, where it has frequently done considerable mischief. It is known to occur in the large pea-growing sections of New Brunswick, Nova Scotia and Ontario, where it first attracted attention near Toronto in 1893, and was found in the pea-growing section of Michigan in 1908. The wings of the adult moth expand about one-half an inch, the fore-wings being "dark, fuscous or dusky, tinged with darker brown and mottled with white," the hind-wings being a uniform fuscous with a rather long inner fringe of hairs, as shown in Fig. 36.

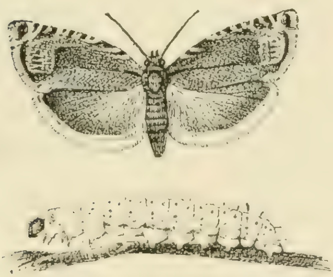


FIG. 236.—The pea-moth (*Semasia nigricana* Steph.): moth above, larva below—about three times natural size. (After Chittenden, U. S. Dept. Agr.)

The females may be found flying around pea-blossoms soon after sunset, and deposit one to three eggs on young pods. The caterpillar hatches in about fourteen days, according to European observations, and attacks the forming seed. Affected pods usually ripen early. The larva is whitish-yellow with a pale brown head

* For description and figure, see 13th Annual Rept. Del. Agr. Exp. Sta., pp. 168–172.

† *Semasia nigricana* Steph. Family *Tortricidæ*.

and thoracic plate, and about one-half an inch long when full grown. With the opening of the pod the larva crawls out and enters the earth, where it spins a very thin silken cocoon. The length of the pupal stage and the method of hibernation do not seem to be well established. Very early and very late varieties are but little injured.

Remedies.—This suggests one of the best means of handling this pest to be the growing of early varieties, such as Alaska, American Wonder, Gregory's Surprise, Nott's Excelsior, and McLean's Little Gem. If the crop is known to be infested, clean up the vines and burn them as soon as it is picked. Dr. Fletcher has made some experiments in spraying for this pest which seem to promise success. One pound of Paris green to 100 gallons of water was used, and it is advised to spray three times; the first when the blossoms begin to fall; the second, a week later; and the third ten days later than that.

CHAPTER XVII

INSECTS INJURIOUS TO BEETS AND SPINACH *

The Beet-aphis †

THIS species was first described by Mr. W. R. Doane in 1900 and seems thus far to have been found only in Washington and Oregon. "Attention was first called to this pest," he says,‡ "in 1896, when it was found that a field of two or three acres of beets was generally infested, a strip of twenty-five to a hundred yards being so badly injured that the beets were nearly all soft and spongy, and the plants much smaller than the average.

"It has been even more destructive in Oregon than in Washington, at least a thousand tons of beets having been destroyed by it in one year in a single valley devoted largely to beet-culture. Like very many other beet-insects, this species infests also several wild or useless plants.

"The smaller rootlets of the beet are first attacked by this aphis, and if it occurs in considerable numbers these are soon all destroyed, and the leaves thereupon soon wither, and the whole beet shrivels and becomes spongy. This wilting of the leaves will frequently, in fact, be the first thing to attract the attention of the beet-grower. The actual injury to the crop will, of course, depend largely upon the time when the attack of the aphis is made. If the plants are small they may be readily destroyed, while if they are practically full grown the loss of the small rootlets will not materially affect them.

* See Forbes and Hart, Bulletin 60, Ill. Agr. Exp. Sta., and F. H. Chittenden, Bulletin 43, n. s., Div. Ent., U. S. Dept. Agr.

† *Pemphigus betæ* Doane. Family *Aphidæ*.

‡ Bulletin No. 42, Wash. Agr. Exp. Sta.

"No sexual generation of this aphis has as yet been discovered and no eggs have been seen, viviparous reproduction continuing throughout the year except when the cold of the winter temporarily suspends the physiological activities of the species. The

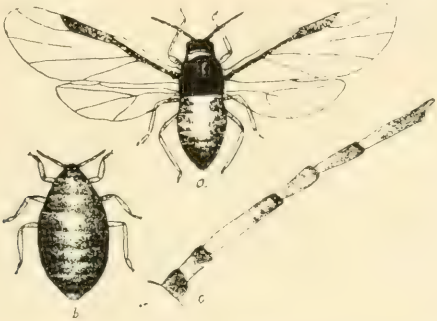


FIG. 237.—The beet-aphis (*Pemphigus betæ* Doane); *a*, winged female; *b*, wingless female; *c*, antenna of winged female. (After Doane.)

winged females, appearing from time to time during the summer and fall, serve to distribute the species generally, new colonies being started wherever these females find lodgment and food. In districts liable to injury by this insect it seems inadvisable that beets should be the first crop on new land, or that ground should be continued in beets or in any other root-crop after the pest has made its appearance in the field."

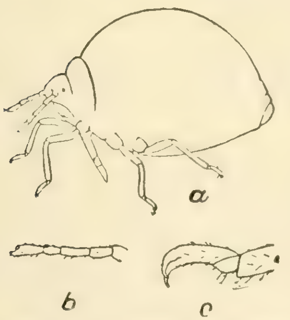


FIG. 238.—Beet root-aphis (*Tychea brevicornis* Hart): *a*, aphis; *b*, antenna; *c*, tarsus—all greatly enlarged. (After Garman).

Another plant-louse, called the beet root-aphis *, proved injurious to sugar-beets in Colorado in 1903. They were found "quite generally distributed in the beet-fields in the vicinity of Rockyford and attacking the roots of many weeds." What seemed to be this species was very abundant upon the roots of the common garden purslane, to which it was very injurious. Near

* *Tychea brevicornis* Hart.

Fort Collins a badly infested field of sugar-beets was also seriously damaged.

No practical means for controlling these pests seems to have been recorded, so that in case of injury the entomologist of the State should be consulted.

White Grubs, Wireworms, and Cutworms

Fortunately for the sugar-beet farmer the worst insect enemies of that plant feed upon the tops, and very rarely do we hear of serious damage being done the roots. In the East most of the damage to the roots is done by those familiar old farm-thieves, the white grub, the cutworm and the wireworm. As a general rule they will be found to be worse on lands previously in sod, which should therefore be avoided when known to be badly infested with either of these insects, as both are difficult to fight after they have once commenced doing noticeable injury.

The life histories and means of control for these pests will be found discussed on pages 79, 84, 85.

The Sugar-beet Webworm *

The sugar-beet webworm is very similar to the garden webworm (page 406), and is so named because it has developed as a serious pest of the sugar-beet in Kansas, Nebraska, and Colorado. It has been noted as injuring tansy in Michigan, and feeds on cabbage, onions, and alfalfa, as well as pigweed (*Chenopodium album*) and careless weed (*Amaranthus*) and will probably feed on many other crops. It is a native of western and central Europe, and northern Asia, and was evidently introduced on the Pacific Coast, as it was noted in Utah in 1869.

The moth is larger than the garden webworm, having a wing expanse of an inch, and is a purplish-brown color with darker and paler bands as shown in Fig. 239. The full-grown larva is about an inch long, of a dark color with a white stripe down the

* *Loxostege sticticalis* Linn. Family *Pyraustidæ*. See C. P. Gillette, Bulletin 98, Colo. Agr. Exp. Sta., and references there given.

back and one along either side, and marked with numerous black and white tubercles as illustrated.

Life History.—The larvæ hibernate over winter an inch or two below the surface of the soil in long silken tubes. In spring they pupate in these tubes and the moths emerge about the middle of May. The eggs are laid on the foliage either singly or in clus-

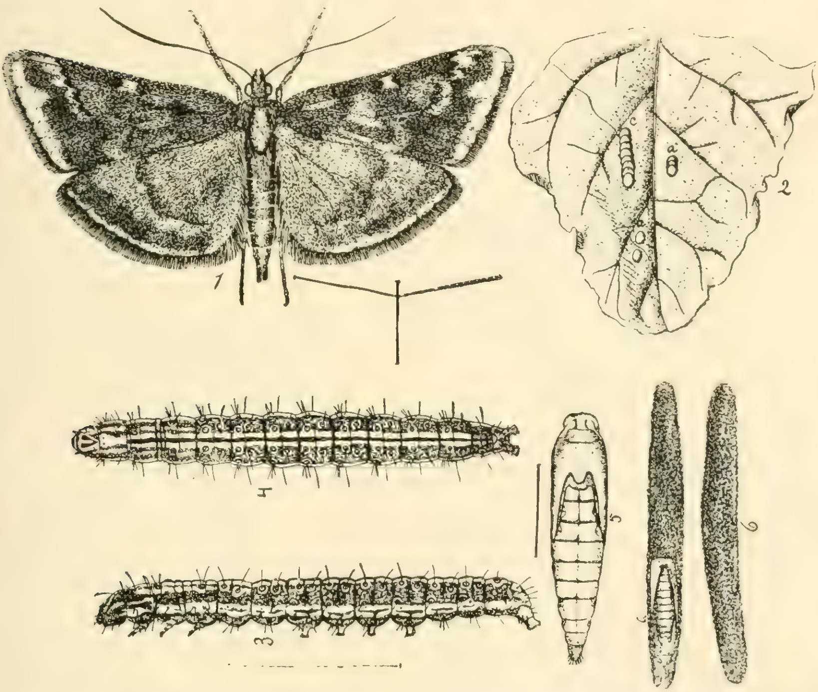


FIG. 239.—The sugar-beet webworm (*Loxostege sticticalis* Linn.): 1, moth; 2, eggs; 3, 4, larvæ; 5, pupa; 6, winter tube of larva, opened at *a* to show pupa—1, 3, 4, 5, enlarged. (After Gillette, Colo. Agr. Exp. Sta.)

ters of from three to ten, one overlapping another. The egg is broadly oval, one twenty-fifth inch long, and of a pale green color. The first generation of caterpillars feed on pigweed and alfalfa in Colorado during June. A second generation of larvæ occurs about the middle of July and sometimes injures beets, but the third generation about the middle of August is

the one most injurious in Colorado. Most of these larvæ hibernate over winter, but there is a partial fourth generation in Colorado. The larvæ defoliate the plants, and cover them with a web the same as the native garden webworm, with which the life history seems to be practically identical.

Control.—The same means of control as for the garden webworm are advised.

The Beet Army Worm *

"This caterpillar, which replaces the fall army worm (*L. frugiperda*—see page 118) in the Western States, differs from

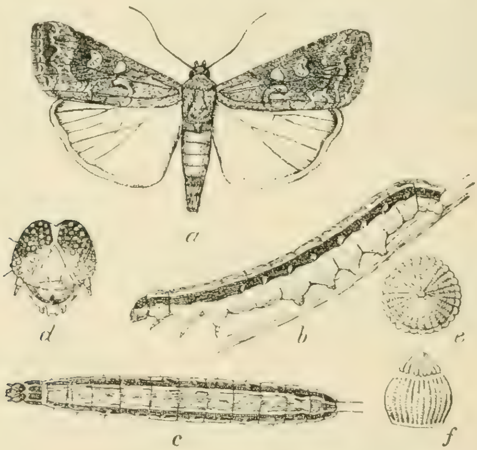


Fig. 240.—The beet army worm (*Laphygma exigua* Hübn.): *a*, moth; *b*, larva, side view; *c*, larva, back view; *d*, head of larva; *e*, egg from above; *f*, egg from side—all enlarged. (After Chittenden, U. S. Dept. Agr.)

it by its more decidedly mottled ground-color, by a row of white dots at the lower margin of the lateral dark band, and by the yellower color of the light stripes. It is an interesting fact that while the preceding species was doing serious, unusual, and wide-extended injury in the Eastern and Southern States (1899), the present one was similarly abundant in Colorado, where, besides destroying many kinds of weeds and grasses, it com-

* *Laphygma exigua* Hbn. Family *Noctuidæ*.

pletely defoliated thousands of acres of sugar-beets. In some cases where the foliage of the beet did not furnish it sufficient food, the root was attacked and the upper surface was completely gnawed away. Late plantings, of course, suffered most severely, especially when surrounded by newly broken ground. The weeds most generally eaten were pigweed, saltweed, wild sunflower, and *Cleome.* Potato, pea, and apple leaves were also devoured. These injuries occurred about the middle of August, at which time the larvæ and pupæ were abundant, and a few moths laden with eggs were noticed."

This species evidenty hibernates as a moth, and at least two broods of larvæ may be looked for each year, the first about June and the second in August. The species has been reported thus far from Colorado and California, but it doubtless has a more extended range in the mountain regions of the far West.

" Professor Gillette's field-experiments showed that it could be destroyed by dusting or spraying arsenical poisons on the leaves."

Flea-beetles

Several species of flea-beetles, chiefly *Systena tæniata*, *Systena hudsonias*, *Disonycha triangularis*, and *Phyllotreta vittata*, often do considerable injury by gnawing small holes in the upper and lower surfaces of the leaves, giving them an appearance as if affected by leaf-spot, or puncturing them full of small holes, and thus stunting the growth of the plant.

The Spinach Flea-beetle *

Of the many species of flea-beetles injurious to sugar-beets, the spinach flea-beetle is one of the largest and most destructive. The beetle is nearly one-quarter inch long, shining black, with a greenish or bluish lustre. The prothorax and abdomen are red or reddish yellow, and the legs and antennæ are pale yellowish. It occurs from New England to Montana and southward to the

* *Disonycha xanthomelæna* Dalm. Family *Chrysomelidæ.* See F. H. Chittenden, Bulletin 43, Bureau of Ent., U. S. Dept. Agr., p. 14; S. A. Forbes, 21st Rept. State Ent. of Ill., p. 116.

Gulf, and is one of the most common pests of beets and spinach, while its native food plants are chickweed and lambsquarters.

Life History.—The beetles hibernate over winter and emerge in the spring during April and May. The buff or orange eggs are laid on end in small masses, "at the bases of the plants infe ted, on bits of leaf or earth, or even within the earth" according to Forbes. The eggs hatch from sometime in April to early July, according to locality. The larvæ usually feed on the under side

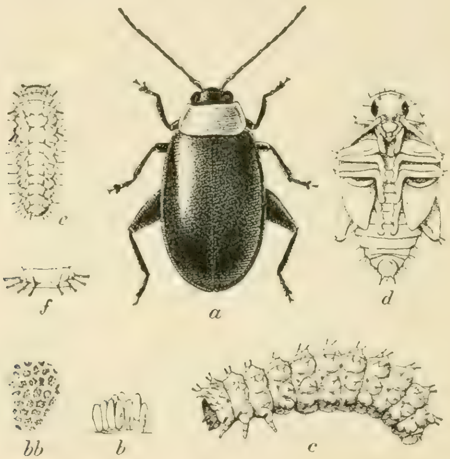


FIG. 241.—The sp'nach flea-beetle (*Disonycha xanthomelæna* Dalm.): *a*, beetle; *b*, egg mass; *bb*, sculpture of egg; *c*, larva; *d*, pupa; *e*, young larva; *f*, abdominal segment of same—*a*, *c*, *d*, five times natural size; *b*, more enlarged; *bb*, *f*, highly magnified. (After Chittenden, U. S. Dept. Agr.)

of the leaf, keeping together in families which migrate from leaf to leaf while young, and drop to the ground—as do the beetles—when disturbed. While young they merely gnaw the under surface of the leaf, but later they eat through and riddle it with round holes, in which they are aided by the beetles. The full-grown larva is about one-quarter inch long, of a dull gray color, except on red and purple beets, on which it assumes the color of the plant attacked, is of a cylindrical form, and the segments are strongly marked by rows of raised tubercles, each of which bears a black hair at the tip. The larvæ become grown

in late June and early July in Illinois, and enter the earth to pupate, the beetles of the next generation emerging about a month after the eggs were deposited. The beetles of the second generation lay their eggs from July to September and the beetles mature before winter sets in. In the District of Columbia, Chittenden observes that the first generation is more abundant on chickweed and the second is injurious to beets and spinach.

Control.—Thoroughly dusting or spraying the plants with Paris green or preferably arsenate of lead will readily destroy the larvæ and probably most of the beetles. As in combating all flea-beetles the destruction of the weeds upon which they multiply is important.

The Larger Beet Leaf-beetle *

One of the principal pests of the sugar-beet in Colorado and adjacent States is a rather large brownish leaf-beetle which with its larvæ destroy the foliage or so injure it that the plant dies. It is often locally known as the "alkali bug" from the fact the injury is mostly on alkali soil or land near it, and "french bug," probably from the "frenching" of the foliage. The beetle is from one-quarter to one-third inch long, and rather resembles the elm leaf-beetle, varying from pale yellow to black, with the wing-covers striped as shown in Fig. 242. Several wild plants, including blites, Russian thistle, and saltbush † probably furnish the normal food of the insect.

"The beetles are gregarious, 'sometimes occurring in swarms like blister-beetles.' Their brownish-gray eggs are deposited in irregular masses, usually on the under sides of the leaves. They hatch in about six days, and their larvæ or young commence feeding at once, continuing for nine or ten days, when they dig their way into the ground, a few days later coming forth as beetles. Although the beetles do much injury, the principal damage is sometimes accomplished by the larvæ, hundreds being found

* *Monoxia puncticollis* Say. Family *Chrysomelidæ*.

† *Dondia americana* and *D. depressa*, *Salsola tragus*, and *Atriplex argentea*.

on a single plant, which is either consumed or so injured that it shrivels and dies. The larva, shown in the illustration, measures when full grown about one-third of an inch in length. The general color is nearly uniform dark olive brown, the conspicuous piliferous tubercles being pale yellow, and the head and portions of the legs black. The eggs are dull brownish gray, and the surface, as seen through a lens, is covered with septagonal and hexagonal areas." *

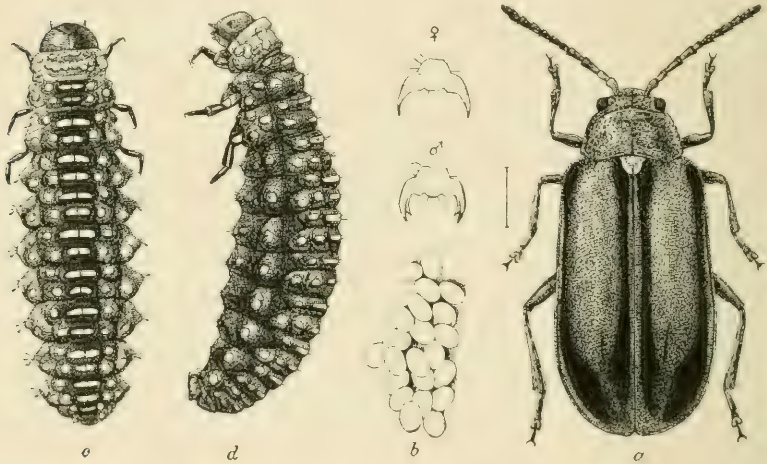


Fig. 242.—The larger beet leaf-beetle (*Monoxia puncticollis* Say): *a*, female beetle; *b*, eggs; *c*, *d*, larvæ from above and side; ♂, claw of male; ♀, claw of female—all much enlarged. (After Chittenden, U. S. Dept. Agr.)

Control.—Paris green diluted with flour and dusted over the foliage has effectively controlled the pest, and probably any thorough application of any arsenical either wet or dry would be effective. Professor C. P. Gillette† has observed that the beetles accumulate on the "mother" beets early in the spring, so that if a few beets were left in the ground over winter they might serve as trap plants for the protection of the younger plants in

* Quoted from F. H. Chittenden, Bulletin 43, Bureau Ent., U. S. Dept. Agr., p. 10.

† C. P. Gillette, 24th Report Colo. Agr. Exp. Sta. (1902), pp. 108–111.

spring. As injury is mostly on or near alkali ground, such soil should be avoided.

Plant-bugs

The Tarnished Plant-bug (*Lygus pratensis*—see page 404), False Chinch-bug (*Nysius angustatus*), and several of the common plant-bugs often become so numerous as to do considerable damage to beets. When present in large numbers, a spray of kerosene emulsion might be used to advantage. Experiments in New York show that the tarnished plant-bug can be driven from a field by dusting the rows with wood-ashes, being careful

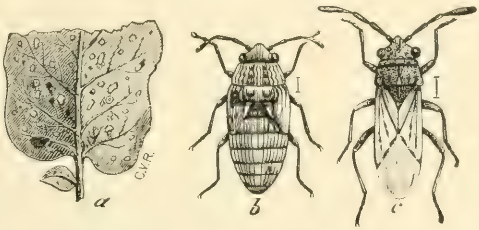


FIG. 243.—The false chinch-bug (*Nysius angustatus*). (After Riley.)

to work on the same side of each row and thus gradually driving them into the field adjoining.

The Beet Leafhopper *

Very serious loss to the sugar-beet industry has occurred in Colorado and Utah from a condition known as "curly leaf" or "blight." Investigations made by Professor E. D. Ball have shown that the "curly leaf" is undoubtedly caused by the presence of immense numbers of small leafhoppers, from 10 to 100 often being found on a plant in badly infested fields. The curly leaf condition does not seem to result, however, except when the soil has become dry and heated, and where plants are shaded or

* *Eutettix tenella* Baker. See E. D. Ball, Bulletin 66, Part IV, Bureau of Entomology, U. S. Dept. Agr.

irrigated the damage by the leafhoppers does not seem to produce the same trouble. Similar injury has been noted in parts of Oregon, but not of so serious a nature.

The beet-leafhopper is a pale yellowish-green species (Fig. 244), one-eighth to three-sixteenths an inch long, and when

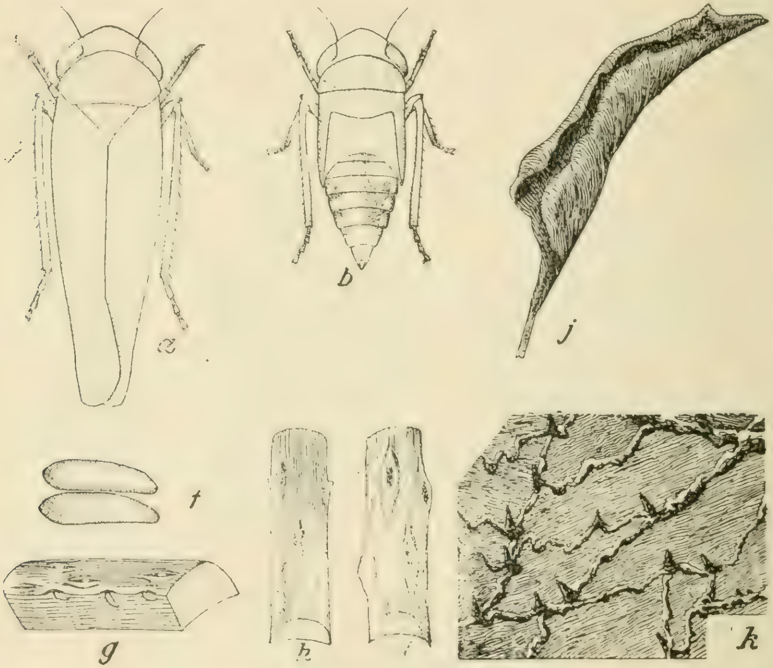


Fig. 244.—The sugarbeet leafhopper (*Eutettix tenella* Baker): *a*, adult; *b*, nymph; *f*, eggs—greatly enlarged; *g*, section of beet stem showing fresh eggs in place; *h*, same showing eggs ready to hatch; *i*, old egg scars on beet stems; *j*, small leaf of sugar beet showing characteristic "curly-leaf" condition; *k*, enlarged section of back of an extreme case of curly-leaf showing warty condition of veins. (After Ball, U. S. Dept. Agr.)

flying appears almost white, so that it is sometimes locally called the "white fly."

Life History.—The hibernating habits of the adults and their food-plants in the spring have not been well determined. They appear in the beet-fields late in June and lay their eggs in the leaf-stems, the eggs hatching in about two weeks. The young

nymphs appear in July and are very active, being first found in the unfolding leaves at the centre and later spreading to all parts of the plant. The nymphs are variously colored, but the commonest form is a pale creamy color with a brown saddle on the middle of the abdomen and various mottlings on the prothorax and wingpads. The nymphs become full grown in from sixteen

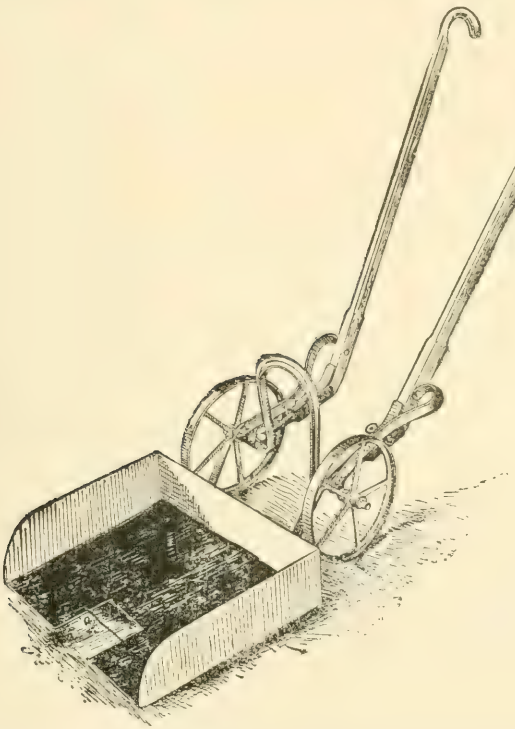


FIG. 245.—"Hopperette" designed for collecting leafhoppers. (After G. C. Davis, Mich. Agr. Exp. Sta.)

to twenty-two days and the adults again become abundant in August and September; they evidently hibernate as adults, as no more eggs are laid in the fall as far as observed.

The characteristics of the "curly leaf" are described by Dr. Ball as follows: "The first symptom of 'curly-leaf' or 'blight' of the beet is a thickening of all the smaller veinlets of the leaf.

giving it a roughened appearance on the under side. This is followed by a curling of the edge and a final rolling up of the leaf, the upper surface always being rolled in. As this progresses the smaller veinlets grow still larger and more irregular, knotlike swellings appear at frequent intervals, and in extreme cases little nipple-like swellings appear, extending to a height of nearly one-fourth of an inch. This will be noticed first on a medium-sized leaf, gradually spreading to the younger ones, while at the same time the beet almost stops growing and a large number of fibrous roots are sent out. . . . The beet often continues in this way throughout the season; in bad cases it shrivels and dies, while in a few instances there is a partial recovery and a new set of leaves, though the sugar content remains very low."

Control.—Practical measures of control do not seem to have been very thoroughly tested. With a better knowledge of the hibernating habits of the species, it may be possible to reduce its numbers at that time. After the hoppers have appeared in numbers they must be dealt with promptly. "A thorough spraying with kerosene emulsion at a strength of 1 part of the stock solution to 5 parts of water, would destroy most of the insects that it hit, and by using a drag in front of the nozzles to turn the leaves over and cause the insects to jump, most of them would be reached." This would probably need to be repeated in about ten days. Hopperdozers have often been successfully used for collecting various forms of leafhoppers. A modification of the form used against grasshoppers (see page 108), with a couple of wings extending out on either side of the row and covered with a sticky substance such as "tanglefoot" or that described on page 523, would undoubtedly prove effective in collecting the adults, particularly before the females have laid their eggs, when they are more readily caught. A "hopperette" designed by Professor G. C. Davis for use against leafhoppers on celery in Michigan, is shown in Fig. 245, and may be readily attached to the frame of a wheel hoe. The string across the notch at A strikes the plants and causes the hoppers to jump at the right time. By adding high wide wings to either side of

this machine it should be well adapted for beets and similar crops.

Blister-beetles *

Among those insects attacking the young sugar-beets and often doing considerable damage after they have become partly grown, few are more widespread or do more general injury than the blister-beetles. They have been especially destructive in the northern Mississippi Valley, where they are usually worst after a period of unusual abundance of grasshoppers. Coming suddenly in a large swarm, they settle in a field and thoroughly

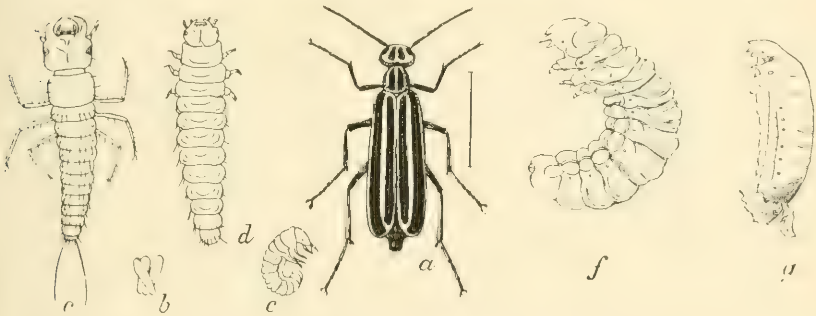


Fig. 246.—The striped blister-beetle (*Epicauta vittata*): *a*, female beetle; *b*, eggs; *c*, triungulin larva; *d*, second or caraboid stage; *e*, same as *f* doubled up as in pod; *f*, scarabæoid stage; *g*, coarctate larva—all except *e* enlarged. (After Riley and Chittenden, U. S. Dept. Agr.)

riddle the foliage with holes or strip it bare before going to another field.

One of the most common forms is the striped blister-beetle, or "old-fashioned potato-bug" (*Epicauta vittata*), which is shown in the illustration, together with the immature stages. The ash-gray blister-beetle (*Macrobasis unicolor*) is also a common form, shown in Fig. 230. Three or four other forms are common throughout the country, but are especially numerous in the West, where grasshoppers are more abundant. The reason for this is apparent when we come to consider the life history of the pest, for the blister-beetles are not an unmixed evil.

* Family *Meloidæ*.

Life History. In a small cavity in the earth the female beetle lays some four or five hundred eggs, these being deposited from July to October. About ten days later the eggs hatch, and from them emerge some small but very active larvae, with long legs, large heads, and strong jaws.

They at once commence running about in search of the pod-like masses of grasshoppers' eggs, and as soon as one is found the larva enters it and commences a hearty meal. As soon as his appetite has been somewhat satisfied he sheds his skin, and now being surrounded by food and no longer needing his long running legs, they are changed for very short, aborted legs, and the larva is soft and sluggish. In another week a second molt takes place, after which the legs and even the mouth-parts are still more atrophied. After another molt and after consuming all the eggs in the pod, the larva now goes deeper in the soil, and inside a small oval cavity again sheds its skin, and hibernates over winter as a sort of semipupa. In the spring the larva appears again much like the second stage, but does not eat much, and soon goes into the pupal stage, from which emerges the adult beetle. Altogether the life history is one of the most peculiar and complicated among insects. Thus the blister-beetles are one of the most important factors in holding the grasshoppers in check.

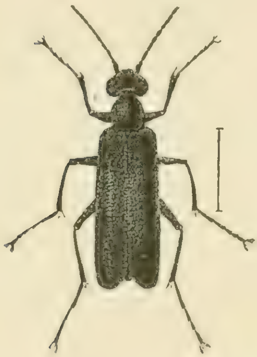


FIG. 247.—The black blister beetle (*Epicauta pennsylvanica*). (After Chittenden, U. S. Dept. Agr.)

Remedies.—However, when they swarm into the beet-fields, potato- or garden-patches, one cannot afford to allow them to consume one crop for the good they may do in saving another from still another insect scourge. "A bird in the hand is worth two in the bush," is equally true of insects. So be ready for them on their first appearance; give the plants a thorough spraying with of 1 pound of Paris green, and 1 pound of lime to 125 gallons of water. It may be well to spray with Bordeaux mixture,

which will prevent various fungous diseases, and with which Paris green can be used much stronger without danger of burning the foliage; or it may be applied dry by mixing with from ten to twenty parts of flour or plaster, dusting it on in early morning, while the dew is still on the plants. Arsenate of lead sprayed at the rate of 3 pounds to 50 gallons, or used as a dust, will be equally effective, will adhere to the foliage better, and will be less likely to burn the foliage.

The Beet or Spinach Leaf-miner.*

Frequently beet and spinach leaves will be found with tortuous mines or large blotches which have been mined out by small white maggots beneath the surface epidermis. This injury is most commonly due to the maggot of a small fly shown in Fig. 248. "The ground color is gray with the front of the head silver white. The body, including the legs, is somewhat sparsely covered with rather long stiff black hairs. When in action the body is usually carried in a somewhat curved position, but when extended measures nearly a quarter of an inch. The maggot (*f*) is white, and so nearly transparent that the contents of the abdomen can be seen through the posterior portion."

Life History.—"The flies, by close observation, may be seen in flight just above the ground or hovering about their different food plants. The eggs are placed on the lower surface of the leaves and arranged in masses of from two to five. When the young hatch they bury themselves within the leaf tissue, constructing a thread-like mine which they afterwards extend in a curve or semicircle. Transformation to pupæ takes place in most cases in loose soil, which the maggots enter to only a short distance, or under fallen leaves. Occasionally maggots transform within a leaf if the latter happens to rest on the ground. Dr. Howard states that the eggs hatch in from three to four days, and the larval stage is passed in seven or eight days, the puparium or resting stage requiring from ten to twenty days.

* *Pegomyia vicina* Lintn. See Chittenden, l.c., from which the quotations are taken.

"Injury appears to be most frequent in late fall, but may be due to earlier generations in midsummer. "In many cases infestation can be traced directly to the insect having bred in lambsquarters and similar weeds, which if not destroyed by ordinary methods of cultivation mature and die during October."

Control.—Where this pest occurs in small gardens it may be controlled by picking and destroying the infested leaves, and

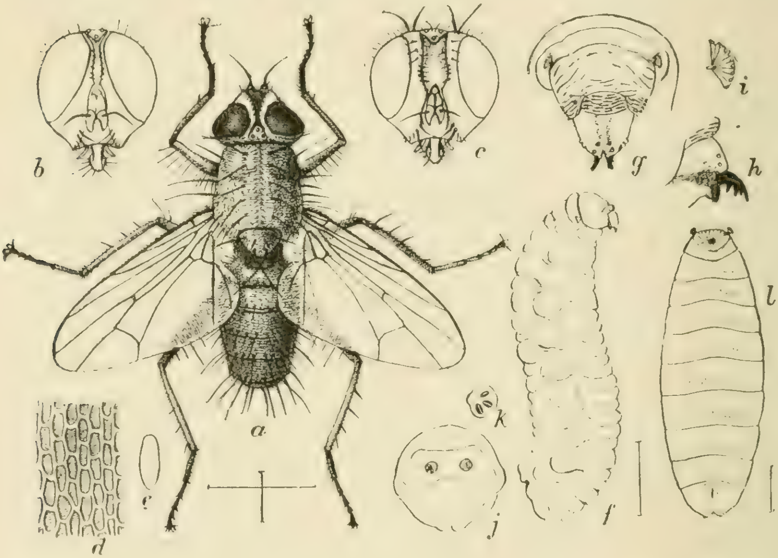


Fig. 248.—The beet leaf-miner (*Pegomyia vicina* Lintn.): *a*, fly; *b*, head of; male fly; *c*, head of female; *d*, surface of egg highly magnified; *e*, egg *f*, maggot; *g*, head of same; *j*, anal segment; *k*, anal spiracles—all enlarged. (After Howard, U. S. Dept. Agr.)

even in larger fields such a practice might prevent its increase and consequent injury. Those insecticides which have been tried as remedies seem to have had no effect. Deep plowing and thorough harrowing of infested fields as soon as the crop can be removed should greatly lessen injury the next year. As this species seems to prefer spinach to beet, Dr. Chittenden has suggested that spinach might be used as a trap crop in large fields of sugar beets where the injury warranted such a measure.

CHAPTER XVIII

INSECTS INJURIOUS TO CABBAGE AND CRUCIFEROUS CROPS *

The Cabbage Maggot †

Throughout the Middle and Northern States the cabbage maggot is one of the most destructive and most difficult to combat of all the insects affecting cabbage, cauliflower and radishes. Just as the plants are commencing to make a good growth they suddenly appear sick, many are found wilting, and soon die. Examination of the roots shows that they have been riddled by small, white maggots as shown in Fig. 254. Early-planted cabbage, cauliflower and radishes are particularly affected, and later in the season the maggots will be found on turnips and wild mustard.

These maggots are the larvæ of a small fly, resembling the house-fly, but distinctly smaller, being only three-sixteenths inch long, with a narrower body and proportionately larger wings. It is a grayish color with three dark stripes on the thorax and one along the middle of the abdomen, and the body bears numerous stiff hairs or bristles. The flies appear just as early cabbage is set out, in late April and early May in New Jersey, and in late May in southern Minnesota. They do not fly far and seem to avoid fields which are swept by the wind.

Life History.—The females deposit their eggs on the stem of the plant or in the soil near the stem, at or just beneath the surface

* See Garman, "Insects Injurious to Cabbage," Bulletin 114, Ky. Agr. Exp. Sta.

† *Pegomyia brassicæ* Bouché. Family *Anthomyiidæ*. See Slingerland, Bulletin 78, Cornell Univ. Agr. Exp. Sta.; J. B. Smith, Bulletin 200, N. J. Agr. Exp. Sta.; F. H. Chittenden, Circular 63, Bureau of Ent., U. S. Dept. Agr.; F. L. Washburn, 11th and 12th Reports State Ent. of Minn.; W. J. Schoene, Bulletins 301 and 334, N. Y. Agr. Exp. Sta., Journal of Economic Entomology, Vol. IV, p. 210.

of the soil, each female laying some fifty eggs. The eggs are most abundant in late May and early June in central New York. Usually a female lays but one or two eggs on a plant and prefers to lay them in a crevice of the stem or very near it, for if the young maggots have to travel far to reach their food, many will die before finding it, and if laid on hard soil the maggots will be unable to penetrate it to the soft tissue of the root, as they are unable to feed on

FIG. 249.—Cabbage root infested with maggots. (After Slingerland.)

the hard stem above ground. The eggs are about one twenty-fifth inch long, of a pure white color, which renders them easily seen against the soil by one familiar with them, and are of the shape shown in Fig. 251, having a curious ridge along one side. The eggs hatch in from three to ten days, averaging five to seven. The little maggots at once commence rasping the surface of the tender roots, gradually mine into them, and in three or four weeks have become full grown. The grown maggot is one-third inch

long, white or yellowish in color, tapering toward the head and obliquely truncate at the tip of the abdomen. From the head a pair of strong, black, hook-like, rasping jaws project downward, and just back of the head on either side is a minute, light brown, fan-like projection (Fig. 253, *b*), or spiracle, which leads into the breathing system. The oblique posterior end is surrounded by

Fig. 250.—The cabbage maggot fly (*Pegomyia brassicæ* Bouché), female greatly enlarged. (After Slingerland.)

twelve rounded tubercles and in the centre are two brownish spiracles (Fig. 253, *a*). When done feeding the larva burrows one-half to one inch under the surface of the soil, and the outer skin gradually hardens until it forms a firm brown shell, called a puparium, within which the larva transforms to a true pupa. Frequently the puparia are found in the galleries made by the maggot or in crevices of the roots. During the summer this stage lasts about two weeks, but in the fall most of the insects remain in this condition over win-

ter. Thus the whole life cycle from egg to adult requires about six to ten or twelve weeks, according to the temperature and moisture, and the second generation of flies appear in June in New Jersey or by mid-July in southern Minnesota. The maggots of the second generation seem to do but little damage. The life history of the insect during late summer has not been satisfactorily determined, but there is undoubtedly a third generation and in the South, possibly a fourth, the work of the last generation being sometimes noticed in late cabbage in early fall. On Long Island, N. Y., the larvæ have been observed as abundant upon cabbage stumps in September and October, working above ground, and the adults and eggs have been common around the adventitious buds. Rough estimates indicate 300 to 1500 maggots per acre on these stumps. The puparia of the last, and in the North possibly some of those of the second generation, remain in the soil over winter, though there is some evidencethat the flies may also hibernate in the Middle States.

Fig. 251.—Egg of cabbage maggot, greatly enlarged; hair line at center of *b* shows natural size; *b*, outline of side view.—(After Slingerland).

Control.—The most effective measures of control consist in cultural methods and preventives, but little practical success having attended the use of remedies to kill the maggots.

Cultural Methods.—Inasmuch as the puparia remain in the soil or in the old roots or stumps over winter, it is important for this as well as other cabbage pests to gather and destroy all the refuse of the crop as soon as possible and then plow infested land thoroughly in the fall. Mr. Schoene has shown that by plowing badly infested seed-beds six or seven inches deep that only one-fourth as many flies emerged as where the soil was undisturbed. A rotation of the crop will be of value where cabbages are not grown on large acreages. Cabbage and other cruciferous crops should not be planted after each other, as all are affected by the same pests. It is evident that if the crop is planted at some distance from that of the previous year, and as the flies are known to avoid wind-swept fields,

that many of them will not succeed in finding the new planting.

As the maggots infest wild mustard and various similar weeds, they should be destroyed as far as possible and crops affected by the maggots should not be planted on or near land badly infested with such weeds if avoidable. Wild mustard may be readily killed by spraying it while young with iron sulfate, 2 pounds to 1 gallon of water.

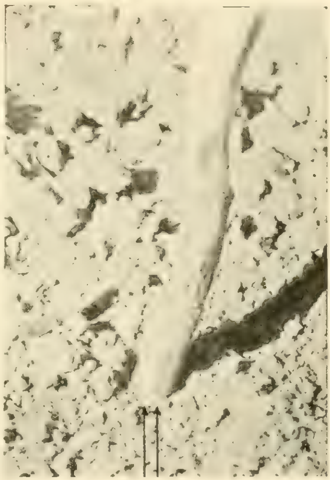


FIG. 252.—Eggs of cabbage maggot at base of stalk. (Photo by Headlee.)

Late-planted cabbage is but slightly affected as compared with that planted earlier. The earliest radishes are often quite free from the pest, those planted later and maturing just as the flies are abundant are badly injured, and the later plantings are free from injury. It is evident, therefore, that where planting of the main crop can be delayed until after most of the flies have oviposited, that it will escape serious injury. Furthermore, either cabbage or radishes may be used as a trap crop, by planting a few rows early and as soon as the flies had laid their eggson them, plowing them under deeply and then setting the main crop. All of these methods involve a familiarity with the fly and its eggs which any observant grower may soon acquire.

High fertilization with a quickly available fertilizer will enable the plants to make a rapid growth and will be profitable even if maggots do not occur.

Thorough and frequent cultivation while the eggs are being laid destroys many of them. Indeed, one of the best means of control, which is extensively practiced by many growers, is to

hill up the earth around the young plants when set, and as soon as eggs are laid, pull the soil containing the eggs away from the plant into the middle of the row, where they or the maggots hatching from them will be killed by the heat. This involves considerable hand work, but where carefully and intelligently followed is one of the surest means of control.

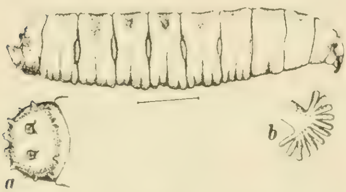


Fig. 253.—Cabbage maggot, side view, enlarged, hair line represents natural size; *a*, view of caudal segment; *b*, outline of spiracle back of head—greatly enlarged. (After Slingerland.)

Preventives. Where late cabbage is grown the plants often become infested in the seed-bed. To avoid this the seed-beds should be covered with cheesecloth. The sides of the frame are made of 12-inch boards, across which wires are stretched to prevent sagging of the cloth, as the whole must be fly-tight. The cover should be removed a week or ten days before transplanting, so that the plants may harden. If eggs are observed in the seed-bed during this time, transplant at once.

The most successful preventive yet used consists of a tarred felt card placed around each plant so as to form a collar, lying upon the surface of the soil and thus preventing the fly from depositing her eggs. These cards were originally devised by Professor W. H. Goff, of Wisconsin, and have been extensively used by large growers in that State for many years, as well as in New York, and recent experiments in New Jersey and Minnesota have proven them very satisfactory. The cards should be made of one-ply tarred felt, as ordinary tarred paper or building paper curls up and is not as effective. The cards are made in a hexagonal shape, with a slit extending from one corner to the centre, which is slit with a star-shaped cut to accommodate the stem. The cards are cut with a tool shown in Fig. 255, which may be made by any blacksmith, and are cut out in rows as illustrated, one cut of the tool making a card. The cards should be placed around the plants when

they are set. The earth should be smoothed down and well firmed by the hand, the card then applied to the plant, and pressed down tight to the ground, so that it fits snugly around the stem and the edges of the slit meet. With a little experience the cards may be applied rapidly, and though involving considerable handwork, the testimony of those who have used them for many years shows that the method is entirely practical and is to be preferred to doubtful remedies.

FIG. 254.—Cabbage roots destroyed by the cabbage maggot. (After Slingerland.)

A mixture of lime and carbolic acid has recently been used by applying it to the surface of the soil around the plants, so as to form a slight crust, the carbolic acid acting possibly as a repellant. The lime is slaked to a thin cream, and diluted to 3 pints to a gallon of water, to which is added a tablespoonful of crude carbolic acid. It is applied liberally to the soil immediately around the plants with a sprinkling can. This has proven quite effective for cabbage in New Jersey, but in Minnesota cabbage so treated showed but little benefit, though radishes were somewhat protected. Kerosene and sand, gas tar and sand, tobacco dust and many other substances

have been used to place around the plant and act as repellants or preventives, but all have some objection or have not been sufficiently tested to show their effectiveness and practicability. Dr. J. B. Smith reports, however, that cauliflower-growers at Richfield, N. J., have been using gas tar, 1 part to 25 parts of sand, for several years with good results. The gas tar costs $1.25 a gallon and will treat 1000 plants. A greater proportion of gas tar has proven injurious.

Remedies.—For the destruction of the maggots, both carbolic acid emulsion and hellebore decoction have been extensively used with varying results, but from the evidence so far submitted, the grower would hardly seem warranted in placing much dependence upon them, though where preventive measures have been neglected, they may aid in reducing the number of maggots and prevent a total loss. To make the emulsion, dissolve 1 pound of soap in a gallon of boiling water; to this add 1 pint of crude carbolic acid and churn thoroughly until a good creamy emulsion is made. For use, dilute one part of the emulsion with 30 parts of water and apply 4 to 6 ounces to each plant. It may be conveniently applied with a watering pot. The earth should be pulled away from the plants so that the emulsion may be brought into actual contact with the larvæ on the roots. Application should be commenced as soon as maggots are observed, repeated in 4 or 5 days, and then once a week for a month. Well-grown maggots are quite resistant to the emulsion, but it will destroy the young as they hatch before

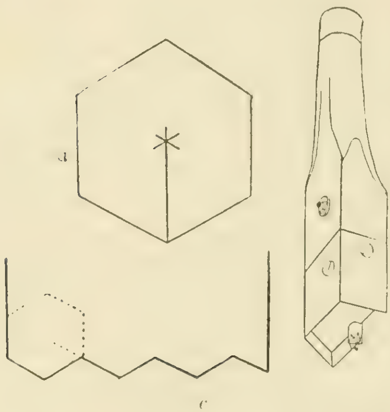


FIG. 255.—*a*, tarred felt card in outline one-third size; *b*, tool for cutting cards, about one-sixth size; *c*, showing how tool is used, dotted line indicating position of edge of tool. (After Goff.)

they become established in the root. Hellebore decoction is made by steeping 2 ounces of powdered hellebore in a quart of boiling water for half an hour, and then diluting to make a gallon of liquid. It may be kept in the concentrated form, but should be thoroughly stirred before using. It is applied in the same manner as the carbolic emulsion. Both these mixtures may also be used against maggots on radishes and onions by making thorough applications along the rows.

The surest method of destroying the maggots on the roots is by the use of carbon bisulfide (see page 57). This is entirely practicable on a few plants, but has not come into general use on a large scale, as no satisfactory tool for its injection into the soil is available. A small hole should be made with a dibble 4 to 6 inches from the infested stem, and a teaspoonful of carbon bisulfide injected and the hole tightly closed with earth. If made too close to the plant the roots will be injured. The fumes kill the maggots by permeating the soil. Where plants are badly infested injection on two sides may be necessary. The material will cost about $1.00 per 1000 plants. Professor Slingerland describes an injector, no longer made, but similar tools are for sale by dealers in agricultural implements in France, and might be made by any machinist.

The Imported Cabbage Worm *

Probably the worst pest of the cabbage and one of the best-known garden insects is the common cabbage worm, whose parent is the common white butterfly. It is an old European pest and was imported near Quebec, Canada, about 1860, whence it spread to New England, reached New York in 1868, Cleveland, Ohio, by 1875, and the Gulf States by 1880, and has since spread to all parts of the country.

The butterflies are among the first to emerge in early spring. They are white, marked with black near the tip of the fore-wings, which expand nearly 2 inches. The female bears two black spots

* *Pontia rapæ* Linn. Family *Pieridæ*. See F. H. Chittenden, Circular 60, Bureau of Entomology, U. S. Dept. Agr.

on each fore-wing, while the male has only one, and both sexes have a black spot on the anterior margin of the hind-wings.

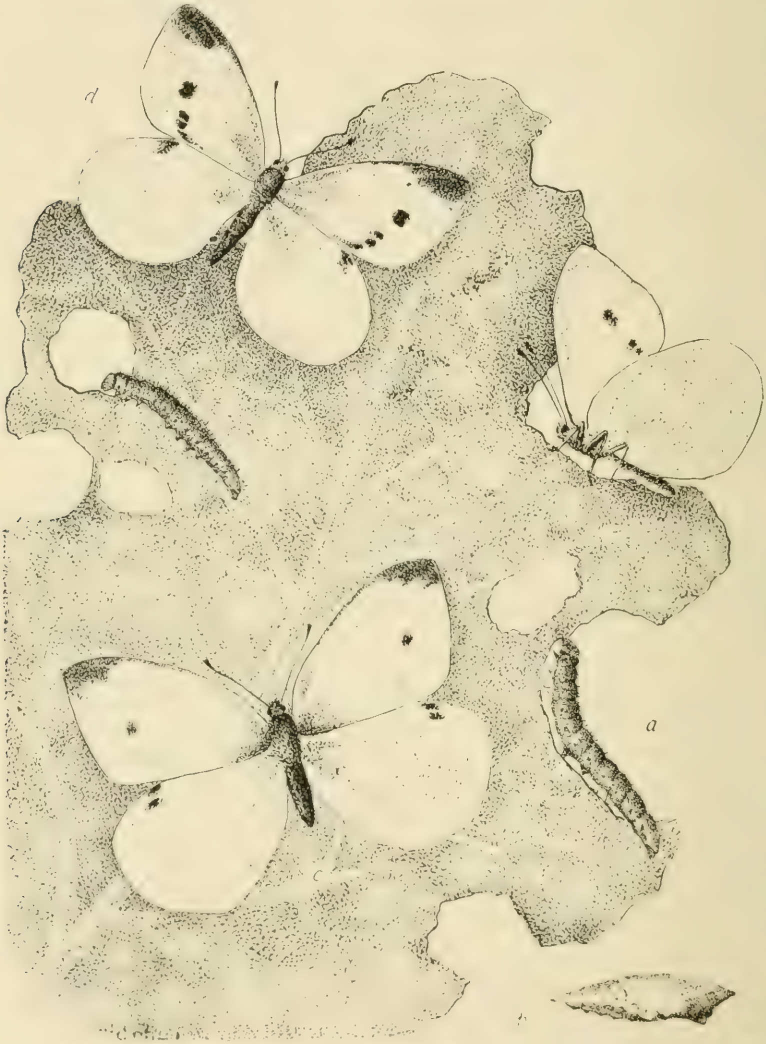


Fig. 256.—The cabbage butterfly (*Pontia rapæ* Linn.): a, larva; b, chrysalis c, male butterfly; d, female butterfly. (After C. M. Weed.)

Life History.—The butterflies soon commence to lay their eggs on whatever food-plant is available. The larvæ feed on all of the

common cultivated crucifers as well as many wild sorts, so that the species is never without food. The small yellowish, oval eggs are laid on end on the foliage, and are marked with prominent longitudinal ridges. They hatch in from four to eight days. The larvæ grow very rapidly, gorging themselves on the foliage, which they skeletonize in their well-known manner, and become full grown in from ten days to two weeks. The mature cabbage worm is about 1¼ inches long, of a velvety green color, very similar to the foliage, with a faint yellow stripe down the middle of the back and a row of yellow spots one each side. The surface, when seen under a lens, is finely roughened and dotted with small black specks. The

FIG. 257.—*Pteromalus puparum*, a chalcis-fly which parasitizes the cabbage worm and many other injurious insects, male and female greatly enlarged—hair line shows natural size. (After Chittenden, U. S. Dept. Agr.)

chrysalis is attached to the foliage by a strand of silk around the thorax and is first greenish and later light brown in color. The butterflies emerge in from one to two weeks in the summer, but the chrysalides of the last generation in fall hibernate over winter among the old stalks and rubbish on the fields. Thus the whole life cycle in summer requires from three to five weeks. In New England there are three generations a season and there are probably five or six in the extreme south, as the butterflies there remain on the wing all winter.

Enemies.—Fortunately, the parasites of the cabbage worm are becoming very effective in checking its multiplication, and in many sections of New England where it has existed the longest, it rarely becomes very injurious, so well do the parasites control

it. Most of these are importations from Europe, one of the most important being a small wasp-like Braconid fly (*Apanteles glomeratus* Linn.) which was purposely imported from England in 1883. During the autumn of 1904 Dr. Chittenden states that it killed practically every worm at Washington, D. C. The maggots of these little parasites live within the worms and when full grown come forth and spin masses of small white cocoons on the foliage, often attached to the dead or dying worm (Fig. 167). Another very important parasite is a minute Chalcis-fly (*Pteromalus*

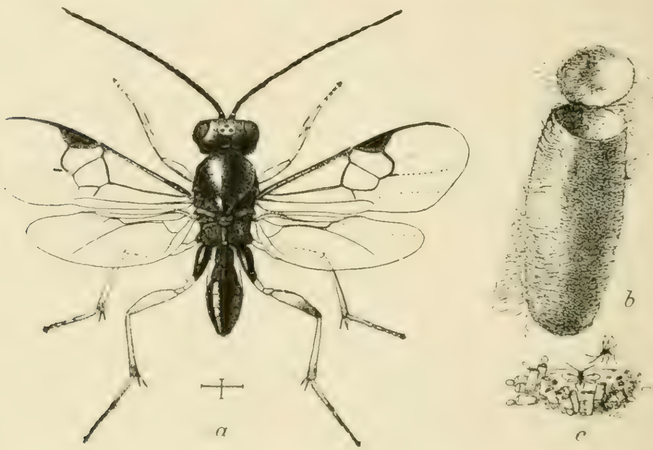


Fig. 258.—*Apanteles glomeratus*, a parasite of the cabbage worm: *a*, adult fly; *b*, cocoon; *c*, flies escaping from cocoons—natural size, *a*, *b*, highly magnified. (After Chittenden, U. S. Dept. Agr.)

puparum Linn.), about one-sixteenth of an inch long, which was probably imported with its host. These often emerge in immense numbers, hundreds of them often being secured from a single worm. Wasps frequently prey on the caterpillars, using them for provisioning their nests. Various predaceous bugs also attack the worms as well as numerous other internal parasites.

Control. As the chrysalids pass the winter on the old stumps, foliage, and rubbish on the field, it is evident that they should be destroyed and the field plowed as soon after the crop is removed as possible. A few stalks may well be left standing here and

there and be kept well poisoned, so as to act as traps to destroy worms from eggs laid by late females.

The most effective means of control is spraying or dusting with Paris green or arsenate of lead. The former is used $\frac{1}{3}$ pound to the barrel and the latter 2 to 3 pounds per barrel of water. As the foliage of cabbage is extremely smooth it will be advisable to add 2 or 3 pounds of resin soap or "sticker" to render the material more adhesive (see page 46). The arsenicals should be applied as soon as the plants are set, and they should be kept well covered until the heads are half formed. If this is done, the young larvæ will be destroyed before they burrow into the heads, and there will be but little damage after the spraying is stopped. Although there is some prejudice against poisoning cabbage, it is entirely unfounded, for it has been shown that a person would need to eat twenty-eight cabbages at once, if dusted in the ordinary manner, to secure poisonous effects. It is obvious that plants should not have large quantities of dust placed on them after they commence to head, and such applications are entirely unnecessary.

Various contact insecticides may be used against the worms on a few plants, but are not practicable for large acreages. Thus water heated to 150° F., will kill all the worms which it hits. Kerosene emulsion will kill the larvæ, but must hit them, and may leave an odor on the plant. Pyrethrum or buhach has been used effectively, applying it either dry or diluted with flour, or sprayed as a decoction at the rate of 1 ounce to a gallon of water. Dilute tobacco extract has also proven effective, but all of these substances have the disadvantage that they must be brought into actual contact with the worms to kill them.

The Southern Cabbage Butterfly *

Before the invasion of the imported cabbage worm this species was the cause of considerable injury from the Middle States southward, but it has now been largely replaced and overshadowed in importance by the imported species. The male butterfly is very similar in marking to the female of *P. rapæ,* and would not

FIG. 259.—The southern cabbage butterfly; *a,* male; *b,* female. (After Riley.)

be distinguished on the wing. The female is more heavily marked with black, as shown in Fig. 259. The caterpillar is a greenish-blue color with four longitudinal, yellow stripes, and

FIG. 260.—The southern cabbage butterfly: *a,* larva; *b,* pupa. (After Riley.)

covered with black dots. The habits are very similar to those of the imported cabbage worm, and the same methods of control should be used.

* *Pontia protodice* Boisd. Family *Pieridæ.*

The Potherb Butterfly *

This species is more common in the North and East and is distinguished from its near relatives by the wings being uniform white without spots. The larvæ are very similar to those of the imported species and the habits are very similar. Like the southern species, though formerly very common and often injurious, this species is now rarely common enough to do much injury and feeds mostly on wild plants. The same remedies as for the imported species should be used.

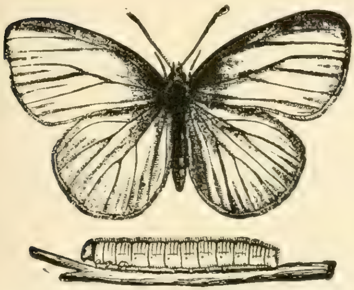


Fig. 261.— The potherb butterfly and caterpillar. (After Harris.)

The Cabbage Looper †

Next to the imported cabbage worm the looper is probably the most serious pest of cabbage and closely resembles it in the way it strips the foliage. The name "looper" is derived from its "looping" habit of walking like a measuring worm, due to the absence of legs on the third and fourth abdominal segments. The larvæ are pale to dark green in color, marked with several longitudinal white lines, as shown in Fig. 262, which become obscure as they become full grown, so that they might be easily mistaken for the common cabbage worms were it not for the looping gait. The species occurs throughout the territory east of the Rockies, but is much more commonly injurious in the Middle and Southern States. Although cabbage and cauliflower are the favorite food plants, it attacks all of the cruciferous crops, is frequently injurious to lettuce, peas, celery and beets, and has been found upon quite a list of cultivated crops and various weeds.

* *Pontia napi* Linn. Family *Pieridæ*.

† *Autographa brassicæ* Riley. Family *Noctuidæ*. See F. H. Chittenden, Bulletin 33, n. s., Div. Ent., U. S. Dept. Agr.; F. A. Sirrine, Bulletin 144, N. Y. Agr. Exp. Sta.

Life History.—The life history has not been carefully observed, but it seems probable that the winter is passed in the pupa stage in the old leaves, stumps and rubbish of the cabbage field. Sirrine states that the life history is similar to that of the imported cabbage worm, and it seems probable that there are three generations a year in the Middle States, and possibly more further South. Injury to cabbage seems to be worse in late summer. When full grown the larva spins a very thin, transparent, white

FIG. 262.—The cabbage looper (*Autographa brassicæ* Riley): *a*, male moth; *b*, egg from above and from side; *c*, full grown larva in natural position feeding; *d*, pupa in cocoon—*a*, *c*, *d*, one-third larger than natural size, *b*, more enlarged. (After Howard and Chittenden, U. S. Dept. Agr.)

cocoon, attached to the leaf upon which it has been feeding and in it transforms to the light-brown pupa. The pupal stage varies from a week in midsummer to three weeks in October, and the pupæ of the last brood hibernate over winter.

The moth has a wing expanse of about 1¼ inches, and the fore-wings are grayish brown mottled with gray, whitish, and blackish, as shown in Figs. 262, 263. Just inside of the centre of the fore-wings is a characteristic white spot. The hind-wings are paler

brown, with the outer border darker, and the margins of both wings are strongly scalloped.

Control.—The same general methods as advised for the imported cabbage worm will effect the control of this species. Sirrine states that dusting the plants with Paris green has not proved satisfactory, but found the use of Paris green with the resin soap

Fig. 263.—The cabbage looper moth at rest from side and from above—natural size.

sticker (page 46) to be very effective. Arsenate of lead is more adhesive and is therefore superior for cabbage, but will be improved by the addition of the "sticker."

The Cross-striped Cabbage Worm *

Throughout the Southeastern and Gulf States the caterpillar of a native moth, known as the Cross-striped Cabbage Worm,

* *Evergestis rimosalis* Guen. Family *Pyralidæ*. See F. H. Chittenden, Bulletin 33, n. s., Div. Ent., U. S. Dept. Agr., p. 54.

occasionally does very similar injury to the imported cabbage worm. The caterpillar is about three-fifths of an inch long, of a bluish-gray color above, with conspicuous cross stripes of black, as shown in the illustration. The parent moth is a pale ochre yellow color; the fore-wings expand about an inch, and are marked with brownish-black, as shown in the illustration, while the hind-wings are nearly transparent except at the outer edge.

Life History.—The caterpillars are to be found on cabbage in late May and early June at Washington, D. C. When full grown they go just below the surface of the earth and there construct

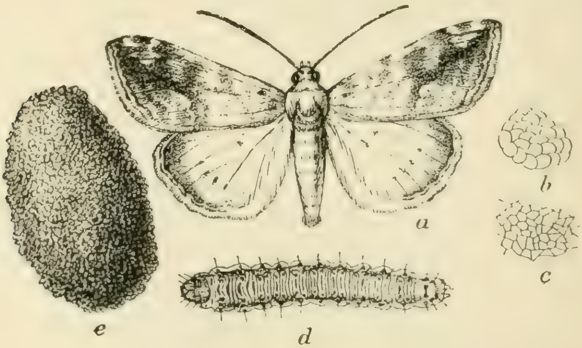


FIG. 264.—The cross-striped cabbage worm (*Evergestis rimosalis*): *a*, moth; *b*, egg-mass; *c*, sculpture of egg; *d*, larva; *e*, cocoon—*a*, *d*, *e*, twice natural size; *b*, much enlarged; *c*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

silken cocoons in which the pupal stage is passed and from which the moths emerge in about ten days. The eggs are laid in masses of a bright light-yellow color, from twenty to forty being laid in a mass on the under surface of the leaf, and hatch in about a week. The caterpillars become full grown in from two to three weeks, so that the full life cycle may be passed in thirty days in midsummer. It seems probable that at Washington, D. C., there are three generations each year, and that the winter is passed in the pupal stage.

Control.—The same means of control advocated for the imported cabbage worm will prove effective for this species.

The Imported Cabbage Webworm *

Sometime in the early 90's another cabbage pest was imported from Europe, where it is common in the Mediterranean region, and was first noted as injurious in South Carolina. Later it was found in Georgia and Alabama, and it is probable that it has now become more generally distributed through the Gulf and South Atlantic States.

The imported cabbage webworm is about one-half an inch long,

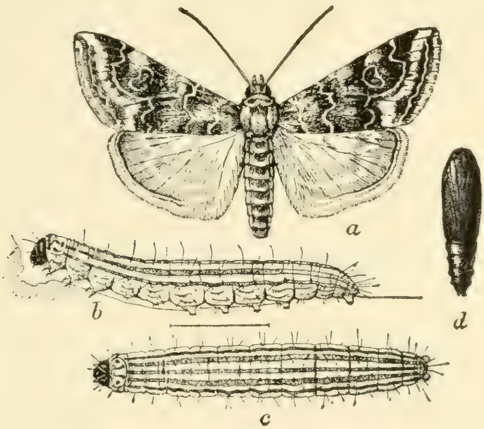


Fig. 265.—The imported cabbage webworm (*Hellula undalis* Fab.): *a*, moth; *b*, larva side view; *c*, larva, back view; *d*, pupa—three times natural size. (After Chittenden, U. S. Dept. Agr.)

of a grayish-yellow color, striped with five brownish-purple bands. Its name is received from its habit of spinning a silken web, beneath which it retreats when not feeding, and to which masses of excreta and frass are attached. Cabbage and turnips have been most injured, but various other cruciferæ are attacked. The parent moth has a wing expanse of about five-eighths of an inch and the fore-wings are of a grayish color, mottled with brown, black and white as shown in the figure.

* *Hellula undalis* Fab. Family *Pyralidæ*. See F. H. Chittenden, Bulletin 19, n. s., Div. Ent., U. S. Dept. Agr., p. 51; Bulletin 23, *Ibid.*, p. 54; W. M. Scott, Bulletin 1, Ga. State Board Entomology, p. 17.

Life History.—The life history has not been followed for the whole season, but all of the stages have been observed. Moths of what seemed to be the first summer generation were obtained in late July. The eggs are about one-twenty-fifth an inch in diameter, oval, and of a grayish color, turning pinkish in a day or two. They are laid singly, usually in the "bud" of the turnip or cabbage. With a temperature of 80° F. they hatched in three days. The caterpillars become full grown in about eighteen days, and then spin thin cocoons between the leaves in which they transform to pupæ. The pupal stage requires but about a week in midsummer, so that the moths emerge just about a month after the eggs were laid. The most serious injury seems to occur in late summer, particularly to young fall cabbage and turnips.

Control.—Use the same measures as advocated for the imported cabbage worm and the cabbage looper.

The Diamond-back Moth *

The larva of the imported diamond-back moth or cabbage plutella are commonly found on cabbage wherever it is grown, and as a rule do but little injury, though occasionally they become troublesome.

"The larva when full grown measures three-tenths inch in length, tapers a little to the extremities, and is of a pale green color. It is active and irritable, in this respect being very different from any of the larger larvæ described." The wings of the parent moth "are kept folded against the sides of the body, are a little turned up at the tips, and are provided with a long fringe. The color above on the head, thorax, and upper part of the closed wings is a light clay-yellow. That part of the wings that is lowest when they are folded is bronzy brown, this color terminating abruptly where it meets the clay-yellow of the back by a well-defined sinuous margin. The length from

* *Plutella maculipennis* Curtis. Family *Tineidæ*.

the front of the head to the tip of the folded wings is about one-fourth inch."*

"The eggs are whitish, very minute, and are attached to the leaves, though sometimes when very abundant they are, it is said, placed on the sides of crates holding cabbage." The full-grown larvæ pupate in small cocoons composed of a delicate lace-work of silken threads through which the whitish, often brown-striped, pupa may be seen. In winter the cocoons containing pupæ are found on old cabbage stalks in the field or on stored cabbage. Two or three generations a year occur in the

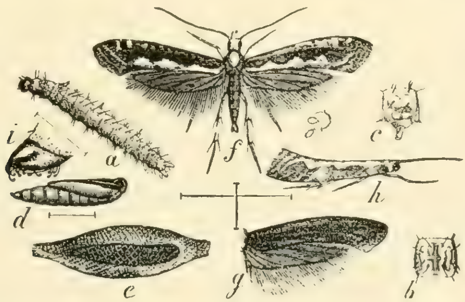


FIG. 266.—The cabbage plutella or diamond-back moth (*Plutella maculipennis* Curtis): *a*, larva; *b*, segment of same greatly enlarged; *d*, pupa; *e*, pupa in cocoon; *f*, adult moth; *g*, wings of dark variety; *h*, moth with wings folded. (After Riley, U. S. Dept. Agr.)

more northern States and four or five generations farther south, while in the extreme South it may be found active practically throughout the year. The species has a world-wide distribution.

"During very dry weather these little insects become exceedingly common, and riddle the cabbage leaves with small holes. Wet weather, on the other hand, has long been known to be unfavorable to them," and drenching the plants with water has been recommended as one of the best means of control. The same remedies applied for the other cabbage worms will readily control this little pest, if necessary.

* H. Garman, Bulletin 114, Ky. Agr. Exp. Sta., p. 29.

The Harlequin Cabbage-bug *

Southern truckers have been familiar with the harlequin cabbage-bug, "calico-back," "terrapin-bug," or "fire-bug," as

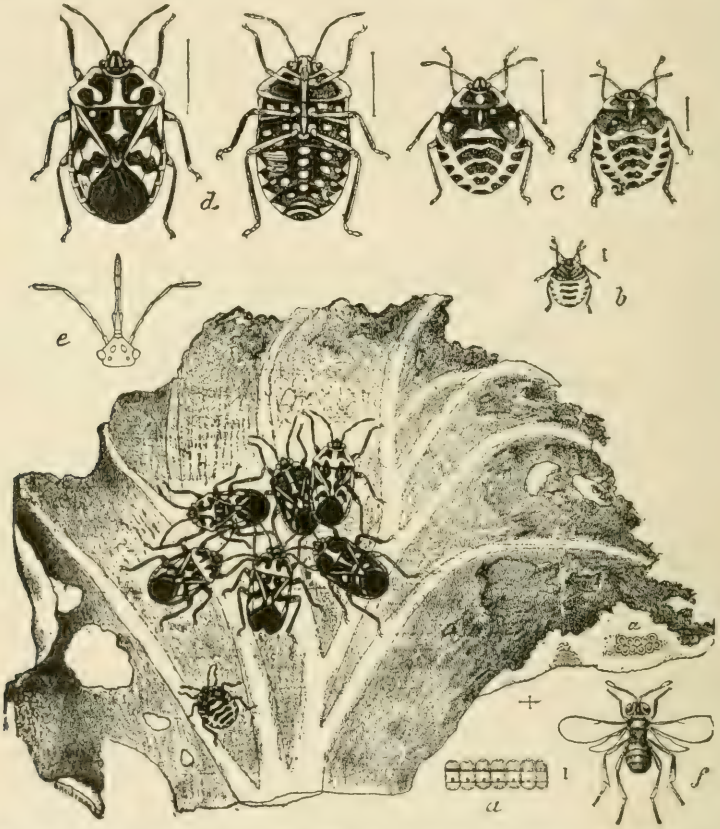


FIG. 267. -The harlequin cabbage bug (*Murgantia histrionica* Hahn.): *a*, eggs -enlarged; *b*, nymphs, more enlarged; *d*, adults seen from above and below enlarged; *e*, head and beak of same; *f*, parasite of eggs—enlarged; bugs and eggs (*a*) on leaf, natural size. (After W. G. Johnson.)

it is variously called, for the past generation. A native of Mexico and Central America, it migrated into Texas about 1864

* *Murgantia histrionica* Hahn. Family *Pentatomidæ*. See F. H. Chittenden, Circular 103, Bureau Entomology, U. S. Dept. Agr.; R. I. Smith, Journal Economic Entomology, Vol. II, p. 108.

and then spread eastward along the Gulf Coast, and northward until it reached Maryland and Virginia, about 1880, New Jersey in the early 90's, and up the Mississippi Valley to southern Ohio and Indiana by 1890. On the Pacific Coast it is found in southern California and Nevada. Although it spread to Long Island, N. Y., southern Pennsylvania, and northern Ohio, and Indiana, its advance was checked by the cold winters of the late

FIG. 268.—Field of cabbage in Delaware ruined by the harlequin bug.

90's and it will probably never become very injurious north of the Potomac and Ohio rivers.

The appearance of the gayly colored bugs, shining black or deep blue, marked with brilliant red or orange, as shown in Fig. 267, is so distinctive that they are readily recognized, and given them the name of harlequin-bug or calico-back. They are about one-half inch long, flattened, and the general shape and markings have given them the local name of "terrapin bug." The bugs suck the sap from the leaves of cabbage and other

crucifers, the plants wilting and dying, and turning black as if they had been swept by fire; hence the name "fire-bug." A half-dozen of the adult bugs will destroy a small plant in a day or two, and as they frequently appear in enormous numbers and as they multiply rapidly, unless they are fought vigorously they will soon destroy a large patch of cabbage.

Life History.—The adults hibernate over winter in old cabbage stumps and under the leaves and other rubbish left on the field, and emerge early the next spring. In South Texas they may be found at work nearly all winter, being common in February and March; in North Carolina they appear about April 1st, and in Maryland about May 1st. The eggs of the first generation are deposited mostly on kale, wild mustard or other wild cruciferæ, each female laying about 100. They are placed in a double row of about a dozen and are white, marked with two black bands and a small spot, which makes them look like small white barrels with black hoops. The eggs of the spring generation hatch in about ten days, and the nymphs feed upon the cabbage for from six to nine weeks before becoming full grown in North Carolina and the District of Columbia, while in the Gulf States the eggs hatch in four to eight days and the nymphs become full grown in three or four weeks, the development of these stages being determined by the temperature. The nymphs are much like the adults in coloration, though differently marked and lacking wings. They molt five times, some of the different stages being shown in the figure. From North Carolina northward there seem to be but three generations of the insect. The summer generation develops more rapidly, the eggs hatching in four or five days, but the fall generation requires about the same time as in spring. In midsummer the whole life cycle may be passed in about two weeks in the Gulf States, according to various authorities, so that there may be a half dozen generations, though the exact life history does not seem to have been observed there.

Control.—This is an exceedingly difficult pest to combat after it has become numerous in the cabbage patch, so that every effort should be made to prevent its appearance. As it hibernates under

old stalks and leaves it is obvious that they should be cleaned up and the field plowed as soon as the crop is harvested. By leaving a few piles of stalks, leaves and rubbish, the bugs might be concentrated and then destroyed.

The most successful method of control yet devised is the use of a trap-crop, to which the bugs are lured as they emerge from hibernation and on which they may be destroyed before they attack the cabbage. Kale planted in the fall or mustard planted early in the spring serves well for a catch crop, and should be planted in rows through the intended cabbage-field. The bugs seem to prefer the kale to the young cabbage, and while concentrated upon it they should be killed by spraying them with pure kerosene. The trap-crop may well be planted at different dates, so that after one row has been destroyed by spraying, another will invite the remaining bugs. The nymphs may be destroyed by spraying them with 15 per cent kerosene emulsion or whale-oil soap, one-half pound per gallon. Whale-oil soap used at the rate of $1\frac{1}{2}$ to 2 pounds to the gallon will kill most of the adult bugs hit by it without injury to the cabbage, but dependence should not be placed upon control by spraying, as its practicability on a large scale is yet to be demonstrated.

The Cabbage-aphis *

Wherever cabbage is grown the common "cabbage-louse" occasionally becomes abundant enough to do serious damage, often destroying young plants, which become covered with the disgusting masses of grayish aphides. They are found commonly in almost every cabbage-patch, but usually their natural enemies are so effective as to prevent their increase; otherwise they would be one of the most serious pests of cruciferous crops. They may be found on all of the cultivated and wild cruciferæ, but cabbages

* *Aphis brassicæ* Linn. Family *Aphididæ*. See C. V. Riley, Report of U. S. Commissioner of Agriculture, 1884, p. 317? C. M. Weed, "Insect Life," Vol. III, p. 289. G. W. Herrick, Journal of Economic Ent., Vol. IV, p. 219? F. H. Chittenden and C. H. Popenoe, Bulletin 2, Va. Truck Exp. Sta., p. 22.

and turnips are injured worst, serious damage often being done to turnips in the South.

"The wingless viviparous female has a rather long oval body, covered with a whitish mealy coat. When this coat has been removed . . . the body is seen to be a grayish-green color, with eight black spots down either side of the back, increasing in size toward the posterior end. The antennæ are green with black tips, and are shorter than the body, and the eyes, legs and tail are black. The young when first hatched are oval, shining, bright yellow in color, and lack the mealy coat. The winged viviparous female is yellowish-green, with the eyes, neck and thoracic lobes black, and the antennæ and nectaries dark brown. The legs are

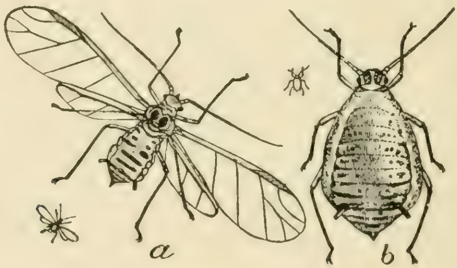


FIG. 269.—The cabbage-aphis (*Aphis brassicæ* Linn.): *a*, winged form; *b* wingless viviparous female—Greatly enlarged. (After Curtis.)

dusky brown and hairy; the tail is dark green or brown and also hairy; the wings are rather short, with stout coarse veins and dark stigma." (Riley).

Life History.—Though the cabbage-aphis is an old European species and was observed in this country as early as the latter part of the eighteenth century, its life history has only recently been carefully worked out by Professor G. W. Herrick and Mr. J.W. Hungate of Cornell University (l.c.), from whose account the following is taken:

The oviparous females appear in the fall and are fertilized by the males, and deposit their eggs in large numbers on the leaves of the cabbage, during October and the first days of November, in central New York. The eggs are laid on rape, turnip, brussels

sprouts and kohl-rabi, but are most abundant on cabbage, particularly in the crevices and depressions of the under surfaces of the leaves. On leaves taken at random from a badly infested patch, from 177 to 293 eggs were found on a leaf. Two to three eggs are laid by each oviparous female. When first laid the eggs are a yellowish-green, but soon turn a shining black. From eggs taken at random and left under normal outdoor conditions, 76 per cent hatched the next spring, while all eggs hatched which were laid by females known to have been fertilized. Eggs hatched about April 1, 1910, in central New York, the season being an early one. From the stem mothers which hatched from these eggs, twenty-one generations of wingless females were reared up to December 3, 1910, the average length of a generation being about twelve days. During the summer generations of winged females are produced, especially on crowded plants, and these serve to spread the pest to unaffected plants. The wingless females become full grown in about thirteen days during the summer and live for about forty-six days, during which time they will give birth to an average of forty-one young, producing as high as six young in a day. The winged forms are much shorter lived, living only about ten days and giving birth to but from seven to thirteen young.

There is no question that in the Southern States the viviparous females may continue to reproduce all winter, and it is quite probable that some of them survive in pits and cellars in the North, where eggs also probably occur. Thus Sirrine* states that it "is certain that this aphid can survive the winter on cabbage stored in cellars or pits, also that cabbage stored in pits for seed purposes furnishes the supply of aphides for infesting the seed stalks in early spring." This being the case it should be an easy matter to destroy the aphides by fumigation before removing them from the pits.

Control.—From the habits outlined it is evident that, as for other cabbage pests, the refuse of the crop should be cleared up and destroyed in the fall. Any of the standard contact insecticides, such as kerosene emulsion, 1 part stock solution to 15 parts of

* F. A. Sirrine, Bulletin 83, N. Y. Agr. Exp. Sta., p. 675.

water, whale oil-soap, 1 pound to 6 gallons, or black leaf-tobacco extract, 1 part to 64 of water, will destroy the aphides, but the spraying must be thorough, as the waxy coating serves to protect them. According to Professor Franklin Sherman, any good laundry soap used at the rate of 1 pound dissolved in 3 gallons of water, will destroy the aphides. Where water under pressure is available in a small garden, the aphides may be held in check by

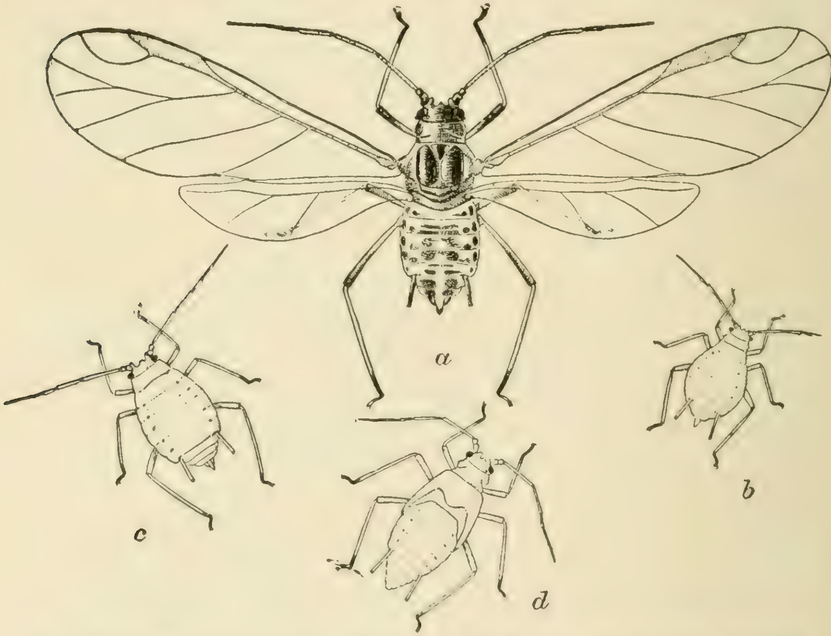


FIG. 270.—The spinach-aphis (*Myzus persicæ* Sulz.): which often becomes a cabbage pest: *a*, winged adult; *b*, young nymph; *c*, older nymph; *d*, last stage of nymph—all greatly enlarged. (After Chittenden, U. S. Dept. Agr.)

washing them from the plants with a strong stream from a garden hose. Plants infested in the seed-bed may be freed from the aphis by dipping in whale-oil soap solution, 1 part to 8 of water.

Fortunately for the grower, the cabbage-aphis is usually held in check by numerous parasitic enemies, principally little wasp-like flies of the family Braconidæ, and by several species of lady-bird-beetles and syrphus-fly larvæ, which will often destroy a colony within a few days.

The Spinach-aphis or Green Peach-aphis *

Another species of aphis often becomes destructive to cabbage, spinach, celery and lettuce, as well as various greenhouse crops. In the fall it migrates to peach, and is also known as the green peach-aphis, as which it is discussed on page 658.

Flea-beetles †

A considerable number of small flea-beetles attack cabbage and other cruciferous crops, and although as a rule only troublesome, they appear periodically in enormous numbers and do serious injury. They are mostly small species (there being seven species of the genus *Phyllotreta* alone) not over an eighth of an inch long. One of the most common throughout the country is the striped turnip flea-beetle.‡ It is polished black with each wing-cover marked with a broad, wavy band of pale yellow. The microscopic white eggs are laid in a little excavation of the root near the crown of the plant. The larvæ mine into the roots and have been reported to do considerable injury to them, but it seems probable that most of them live upon the roots of cruciferous weeds. The full grown larva (Fig. 270, *a*) is about three-eighths inch long, quite slender and tapering, yellowish white, with brown head and anal plate, and with marks on the thorax and transverse rows of minute hair-bearing tubercles as shown in the figure. The Western cabbage flea-beetle § is the more common from the Dakotas southward to Mexico and westward to southern California. It is a uniform deep olive-green, with the surface irregularly punctate, and $^{7}/_{100}$ inch long. Another species almost indistinguishable from the first species above, is the wavy-striped flea-beetle,¶ whose larvæ mine in the leaves of wild pepper grass (*Lepidium virginicum*),

* *Myzus persicæ* Sulz. See footnote on page 658.

† Family *Chrysomelidæ*. Refer to pages 296, 335, for other flea-beetles. See. C. V. Riley, Report U. S. Commissioner Agr., for 1884, pp. 301–308.

‡ *Phyllotreta vittata* Fab.

§ *Phyllotreta pusilla* Horn.

¶ *Phyllotreta sinuata* Steph. (*zimmermani* Crotch.)

and is most abundant in the Middle and Southern States. The life history has been fully described by Dr. Riley (l.c.).

Control.—Where the plants are sprayed for the cabbage worms with Paris green or arsenate of lead, there will probably be little trouble with flea-beetles. Otherwise, spray with arsenate of lead, 3 to 5 pounds per barrel, or Paris green one-third to one-half pound, adding the resin soap (see page 46) or "sticker," so as to give the foliage a good thick coating, for the spray probably acts fully as much as a repellant as a remedy. Where injury is anticipated it will be well to dip the plants in arsenate of lead 1 pound

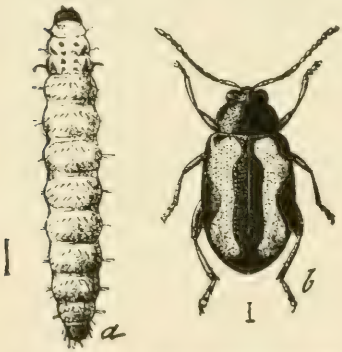


Fig. 271.—The striped turnip flea-beetle (*Phyllotreta vittata* Fab.): *a*, larva; *b*, adult—greatly enlarged. (After Riley, U. S. D. Agr.)

Fig. 272.—The western cabbage flea-beetle—much enlarged. (After Riley, U. S. Dept. Agr.)

to 10 gallons of water when planting them. By thoroughly dusting the plants with lime, land plaster, strong tobacco dust, dilute pyrethrum, or any of the dusts commonly used for such insects, applying the dust in the early morning while the dew is on the plants, they may be protected from attack as long as they are kept thoroughly covered. It is evident that the weeds upon which these pests develop in the larval stage should be destroyed. Where plants are attacked in the seed-bed, screening as advised for the root-maggot will prevent injury. Cloth with from 20 to 30 threads to the inch has proven most satisfactory for the screens, which should be applied early and be made perfectly tight.

The Cabbage Curculio *

A small weevil has proven injurious to early cabbage, particularly in seed-beds, in Wisconsin, Ohio, and Missouri and elsewhere. The cabbage curculio is a native of middle and northern Europe, where it is not known as doing much injury, and was first noticed in this country in Massachusetts in 1873. Since then it has spread over the Northern States and occurs in California.

The adult weevil is of a broad, oval shape, about one-eighth inch long, and is covered with grayish scales, but is blackish when

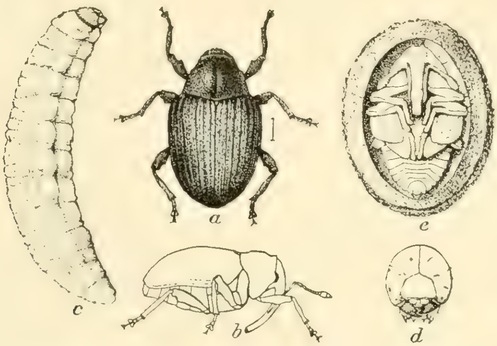


FIG. 273.—The cabbage curculio (*Ceutorhynchus rapæ* Gyll.): *a*, beetle; *b*, same in profile; *c*, larva; *d*, head of same; e, pupa in cocoon; *a*, *b*, *c*, *e*, eight times natural size; *d*, more enlarged. (After Chittenden, U. S. D. Agr.)

these are rubbed off in old specimens. The weevils appear about the middle of April at Washington, D. C., and lay their eggs in the leaf stalks late in April. The grayish, oval egg is about one thirty-fifth inch long, and is inserted in a cavity eaten out by the female, which causes a very noticeable scar. The eggs hatch in about a week. The white, footless larvæ are about one-fourth inch long and bore into the leaf-stems and stalks. "Larvæ are found most numerous in the upper portion of stems, penetrating frequently as

* *Ceutorhyncus rapæ* Gyll. Family *Curculionidæ*. See F. H. Chittenden, Bulletin 23, n. s., Bureau of Ent., U. S. Dept. Agr., p. 39, and F. M. Webster, Bulletin 77, Ohio Agr. Exp. Sta., p. 50.

high as the diameter of the stem will admit them. They also bore into the branches, and occasionally a short distance into the leaf-stalks. . . . In many cases the leaf-stalks are killed or are so injured that they part from the stems when the latter are pulled up; and again, the stems, being so closely tunneled, often part above the middle, even dropping over, though not handled." The larvæ complete their growth in about three weeks, cut their way out of the stalks and enter the earth, where they form small earthen cocoons just beneath the surface. In these they transform to pupæ, from which the beetles emerge in about a week. The beetles are common in the middle of June at Washington, but disappear late in the month.

A fortunate fact is that " cabbage appears to be one of the last plants attacked in the field when any other palatable crucifer is obtainable. The beetles not only greatly preferred hedge mustard (*Sisymbrium officinale*), and wild pepper grass, but appeared to attack also, by preference, turnip, horseradish and cauliflower."*

Control.—This fact of the preference of the beetles for the wild food-plants might be utilized by using them as a trap-crop, planting them, if necessary, as advised for the harlequin cabbage-bug (page 371), and then removing and destroying them as soon as the beetles had oviposited, which would probably be about the middle of May in the latitude of Washington, D. C. Although no practical experiments in its use seem to have been tried, a thorough application of arsenate of lead at from 3 to 5 pounds to 50 gallons would undoubtedly destroy many of the beetles when they are feeding on the foliage in early spring and after they emerge in June.

* Quotations from Chittenden, l.c.

CHAPTER XIX

INSECTS INJURIOUS TO MELONS, CUCUMBERS, SQUASH, ETC.*

The Striped Cucumber-beetle †

JUST as the little cucumber and melon plants appear above the soil they are attacked by hordes of hungry black-and-yellow-striped beetles, which feed ravenously upon the succulent seed-leaves,

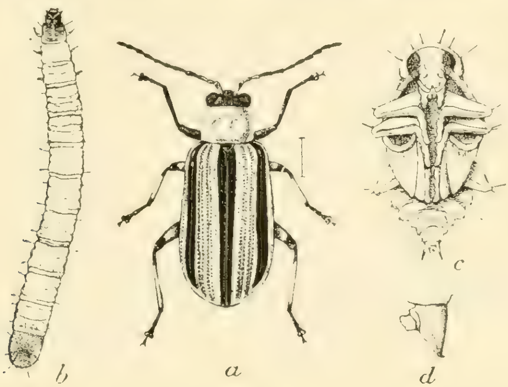


FIG. 274.—The striped cucumber beetle (*Diabrotica vittata* Fab.): *a*, beetle; *b*, larva; *c*, pupa; *d*, egg; *e*, sculpture of egg—*a*, *b*, *c*, much enlarged; *d*, more enlarged; *e*, highly magnified. (After Chittenden, U. S. D. Agr.)

often killing them entirely so that reseeding is necessary. This little striped beetle, often known as the "striped-bug" or "melon-bug," is well known to all growers of cucurbs east of the Rocky Mountains, and also occurs in Washington.

* See A. L. Quaintance, Bulletin 45, Geo. Agr. Exp. Sta.; J. B. Smith, Bulletin 94, N. J. Agr. Exp. Sta..; R. I. Smith, Bulletins 205 and 214, No. Car. Agr. Exp. Sta.

† *Diabrotica vittata* Fab. Family *Chrysomelidæ*. See F. H. Chittenden, Circular 31, Bureau Ent., U. S. Dept. Agr.; T. J. Headlee, 20th Report N. H. Agr. Exp. Sta., p. 499.

The beetle is about two-fifths inch long and half as wide, of a bright yellow color with a black head and three black stripes on the wing-covers.

Life History.—The beetles hibernate over winter in the ground where they have been feeding the previous fall, or along the edge of woodlands, or wherever suitable shelter is obtained, and emerge in the spring two or three weeks before cucurbs are planted. At this season they seem to feed on almost anything, as they have been observed feeding on a long list of food-plants, freque ting flowers whose petals are eaten. As soon as squash, melons, or cucumbers break through the soil, they gather upon them and refuse all other food. If the foliage is covered with any offensive substance they will seek out spots which have not been reached and feed upon them, which fact is of importance in considering remedies. After feeding upon cucurbs for a few days the beetles pair and the females commence to deposit eggs. The eggs are deposited singly and are merely dropped in crevices of the soil or in the opening around the stem of the plant. The egg is oval, about one-fortieth inch long, bright yellow, and sculptured with microscopic hexagonal pits. A female lays about one hundred eggs during a period of a month, and they hatch in about eight days at a mean temperature of 74° F. The larva is a slender, white, worm-like grub, about three-tenths inch long, with dark-brown head and anal-plate, and lighter brown thorax. The larvæ bore into the roots, often tunneling into the base of the stem, and sometimes mine into melons lying on damp soil. Rarely does injury by the larvæ become noticeable, though we have observed whole patches of cucumber and melon vines killed by them, which

Fig. 275.—Larva of striped cucumber beetle at work in cucumber stem. (Photo by Headlee.)

seems remarkable, considering the immense numbers of the beetles which must give rise to many times more larvæ. The larva becomes full grown in about a month and then forms a delicate earthen cell just below the surface of the soil and in it transforms to the whitish pupa, from which the beetle emerges in from one to two weeks, according to the temperature. In southern New Hampshire the beetles emerge from the last of August to the first of October, the complete life cycle requiring from seven to nine weeks, there being but one generation a year, and this seems to be true in New York. In Kentucky the complete cycle requires but

FIG. 276.—Wire screen cover for young cucurbs. (After Headlee.)

thirty-nine days, and in the District of Columbia newly emerged beetles are found by mid-July, so that there are undoubtedly two generations in that latitude, as the beetles have been found pairing and with well-developed eggs in Delaware, August 1st. In the latter part of the season the beetles feed on the blossoms and pollen, particularly of squash, rarely touching the foliage. With the first frosty nights they seek shelter under the fallen leaves and enter hibernation with the first killing frosts.

Control.—For a few plants or where the beetles are unusually abundant, coverings of netting have always been used to protect the plants. A barrel hoop cut in two, crossed, and the ends fastened to another hoop, and the whole then covered with netting,

makes an admirable cover, often sold by dealers. Two stout wires bent into arches and crossed, may also be covered with netting, the lower edge of which is held by earth packed over the edges. Or cone-shaped covers may be fashioned out of wire screening and kept from year to year. (See Headlee, l.c.)

Many growers obviate loss of plants and the necessity of replanting by sowing the seed in rows rather thickly and then thinning out to the desired distance after the worst injury by the beetle is passed. Others make several plantings in each hill at intervals of a week, but the former plan will ensure earlier growth.

The growing of rows of early beans to act as a trap-crop has been suggested, as the beetles will gather on them, it is said, and having an abundance of food will not injure the cucurbits. Squash may be effectively used in this way as the beetles are peculiarly fond of the quick-growing squash seedlings. A week or ten days before the regular crop, plant rows of squash seed around and through the prospective field, and plant more rows when the regular crop is planted. If the main crop be kept well dusted or sprayed as advised below, the beetles will concentrate on the trap-squash and might be destroyed upon it by spraying with pure kerosene.

Liberal fertilization with quick-acting fertilizers will aid the young plants to make a quick growth and thus outgrow the injury.

Growers have long known that if the plants are kept thoroughly covered with some sort of dust that the beetles will not molest them, and various sprays have been used in the same way To be effective the plants must be dusted in early morning while the dew is on and all parts of the plant, above and below, must be thoroughly covered. This must be repeated as often as the dust is washed or blown off, or the plant outgrows it. Air-slaked lime mixed with sulfur, tobacco dust, and bug-death have been the most effective, though similar powders will be found beneficial. Bordeaux mixture has been recommended for this purpose, but seems to have a stunting effect on the young plants. The most valuable repellant seems to be a spray of arsenate of lead 3 to 5 pounds per barrel. This not only repels the beetles better than any other

substance tested by Dr. Headlee, but undoubtedly kills many of those which are forced to feed upon it. Professor Gillette reports that dry pyrethrum dusted on the plants while the dew is on will kill many of the insects. Sirrine found that in New York the beetles could be poisoned successfully with Paris green, but only while feeding in the spring before they commenced to pair, and in the fall, as they refused protected foliage after pairing commenced. Various repellants, such as kerosene, turpentine, naphthalene or moth balls, and other similar odoriferous substances, have been strongly recommended, but careful tests have not demonstrated their efficiency.

It is evident that the cleaning up of vines as soon as the crop can be gathered and the destruction of all refuse will deprive the beetles of food in the fall and force them to seek other hibernating places, thus increasing the mortality.

The Melon-aphis *

Just as the vines commence to run, a plant will be found here and there with the foliage curled up and wilting and within will be found masses of the greenish " melon lice," which have caused the injury by their many beaks sucking out the sap of the plant. If allowed to multiply unchecked and their natural enemies do not prevent their increase, they will sometimes become so abundant as to completely ruin a whole crop just as the melons are commencing to ripen. It is one of the worst pests of cucurbs and one which requires constant vigilance on the part of the grower.

The aphides are to be found on various weeds in early spring and appear on cucurbs soon after they start growth. Both winged and wingless females occur throughout the year. The wingless form is about one-fifteenth inch long and varies from light yellow or tan colored to deep olive-green or deep green which appears almost blackish, the abdomen being always more or less mottled. The rather long, tapering, honey-tubes are jet black, and the legs and antennæ pale whitish-yellow. The young nymphs always

* *Aphis gossypii* Glover. Family *Aphididæ*. See F. H. Chittenden, Circular 80, Bureau of Ent., U. S. Dept. Agr.

show a distinct yellowish-brown or pale salmon-colored area just in front of the honey-tubes and a dark transverse band between them. The nymphs of the last stage, in which the wing pads are visible, are marked on the back with little flecks of silvery white, waxy bloom. The winged female is about the same length and the wings expand one-fifth to one-quarter inch. The color varies as

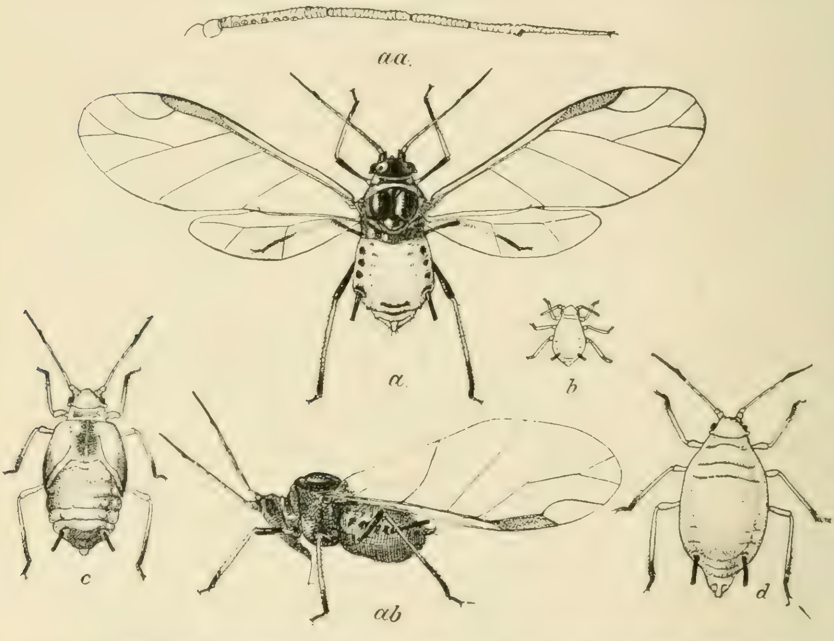


FIG. 277. The melon aphis (*Aphis gossypii* Glov.): *a*, winged female; *aa*, enlarged antenna of same; *ab*, dark female, side view, sucking juice from leaf; *b*, young nymph; *c*, last stage of nymph of winged form; *d*, wingless female—greatly enlarged. (After Chittenden, U. S. D. Agr.)

in the wingless form, but there are black spots along the sides of the abdomen, and the head and thorax are dark as shown in Fig. 277.

The melon-aphis is found throughout the country southward through Central America, and though it often does serious damage in the North it is worse in the South. It has a long list of food plants, among the crops injured by it being all the cucurbs, cotton,

okra, orange, and its occasional food-plants include many others, as it is found on a long list of weeds, most abundantly on shepherd's purse and pepper-grass, upon which it multiplies in early spring and probably passes the winter.

Life History.—The life history is much the same as that of most of our common aphides, though of some phases we are still in ignorance in spite of the most careful study. The females give birth to from four to ten aphides a day, depending upon the temperature and food supply, and these become full grown in from six to eight days. As the affected leaf becomes non-succulent the aphides migrate to another leaf and often cluster on the terminal, which is checked and stunted. As they become more numerous, winged forms migrate to other plants and within two weeks a colony of fifty or more will form the progeny of every one born by the immigrating female. Reproduction seems to go on this way throughout the year, being stopped only by the cold of winter, as far as has been observed. No true sexual forms or eggs, as are known to occur with other nearly related species, have been observed, and the viviparous forms have been found throughout the winter in Colorado and Texas.

Enemies.—Fortunately the melon-aphis is subject to the unremitting attack of many insect enemies, the list including some thirty-five species. Among the more important are the common ladybird-beetles and their larvæ, of which the convergent ladybird,* the nine-spotted ladybird,† and the spotted ladybird,‡ shown in Figs. 1–5, are among the most effective, and the maggots of various common syrphus-flies, and the aphis-lions.§ Even more beneficial are the little parasitic flies whose larvæ live within the maggots and destroy myriads of them with incredible swiftness. The most common of these ¶ are the same as the most common parasite of the green bug (Fig. 113), and they often destroy the aphides over a whole field in a few days. They are most effect-

* *Hippodamia convergens* Guer.

† *Coccinella 9-notata* Herbst.

‡ *Megilla maculata* DeG. Family *Coccinellidæ*.

§ Family *Chrysopidæ*.

¶ *Lysiphlebus testaceipes* Cress. Family *Braconidæ*.

FIG. 278. Melon aphides which have been killed by parasites on cotton leaf.

ive in bright, warm weather, when they reproduce most rapidly, but in cool, moist weather they reproduce but slowly, and if such a summer follows similar weather conditions during the spring, the aphides multiply rapidly without a corresponding increase of their enemies and serious damage results. Inasmuch as these same enemies attack the cabbage-aphis, Professor C. E. Sanborn * has suggested that the cabbage-aphis might be encouraged to multiply on crops planted near melons or cucumbers, so that an abundance of parasites and insect enemies might be in readiness to attack the melon-aphis when it appears. This might be done by planting kale, rape, or wild mustard in the fall, upon which the cabbage-aphides will pass the winter and will multiply in early spring. This trap-crop should be planted in rows around the prospective melon-field, and if the latter be large, rows should be planted through it. If the kale does not soon become infested with the cabbage-aphis, transport some from the nearest cabbage-patch. The ladybirds and parasites multiply rapidly with plenty of the cabbage-aphides for food, and as soon as the food supply becomes scarce they are forced to migrate and will search out any colonies of melon-aphides.

Control.—The most important factor in the control of this, as well as many other aphides, is constant watchfulness, inspecting the plants frequently and destroying badly infested individual plants and treating small areas before the pest becomes spread throughout the crop.

Where a few young plants are affected or before the leaves have become badly curled, the aphides may be destroyed by spraying with kerosene emulsion, containing 5 to 8 per cent kerosene, whale-oil soap, 1 pound to 5 gallons of water, or tobacco extracts. Emulsion must be carefully made or burning will result. The aphides must be hit to destroy them, and it is necessary to use an underspray nozzle (page 75), or to turn the vines over and then re-turn them, so that all the aphides may be covered. After the foliage is well curled it is practically impossible to reach the aphides by spraying, and fumigation must be used.

* See Bulletin 89, Texas Agr. Exp. Sta., p. 44.

Fumigation is much the most satisfactory method of destroying the aphides, for it will kill them all even though the leaves be curled. Carbon bisulfide was formerly used quite extensively for this purpose, a teaspoonful being applied for each cubic foot of space under the tub, box, or cover used. Recently, however, it has been shown that tobacco paper is a much more satisfactory fumigant and it has been extensively used with excellent results. A light frame is made large enough to cover the size of plants to be treated and covered with cheap muslin which is sized with oil. The cloth should extend on the ground for about a foot, so that it may be covered with earth. One man can look after about ten frames. After the frame is placed over the plant a sheet or half sheet of the tobacco-paper (according to the brand used and experience with it) is torn in two and a half placed in perforated tin cans in opposite corners of the frame, and ignited. Earth is then heaped over the flap and the fumigation should continue ten to thirty minutes, according to the strength used, and other conditions, as experience will determine. This treatment has the advantage that it destroys all of the aphides while the predaceous and parasitic insects are merely stupefied and soon revive and feed on any remaining aphides. "Fumigating-kind" tobacco powder might probably be used instead of paper and is used very extensively for the same purpose in fumigating green-houses for this pest. Many tobacco preparations are on the market for greenhouse fumigation and will usually be found satisfactory when used as directed.

The Squash-bug *

About the time the vines begin to run a wilted leaf is found here and there which examination shows to be due to the common brownish-black squash-bug. If search be made in early morning, the bugs will usually be found secreted under clods of earth, or

* *Anasa tristis* DeG. Family *Coreidæ*. See Weed and Conradi, Bulletin 89, N. H. Agr. Exp. Sta.; F. H. Chittenden, Circular 39, Div. Ent., U. S. Dept. Agr.

FIG. 279.—Squash-bugs and nymphs at work on young plant—natural size.

whatever rubbish may be near the vines. They are about three-quarters inch long, and too well known to need other description.

Life History.—For the next month or six weeks the females deposit their eggs, mostly on the under sides of the leaves. They are oval, about one-sixteenth inch long, laid in irregularly shaped clusters. When newly laid they are pale yellow-brown, but this soon grows darker, so that the stage of their development may be told by the color. In from six to fifteen days, depending upon the temperature, the eggs hatch. The young nymphs are brilliantly colored, the antennæ and legs being bright crimson, the head and anterior thorax a lighter crimson, and the posterior thorax and abdomen a bright green, but in a little while the crimson changes to a jet black. The young bugs remain near each other, sucking the juices from the foliage and soon causing the leaves to wither. During their growth, which requires four to five weeks, they moult some five times. The adult bugs appear in August, but in the North they neither mate nor lay eggs that season, but feed until frosts blacken the leaves, when they disappear into winter quarters, hibernating along the edge of woodlands, beneath leaves, under logs, boards or whatever shelter may be available. In the South there are probably two or three broods a year according to the latitude.

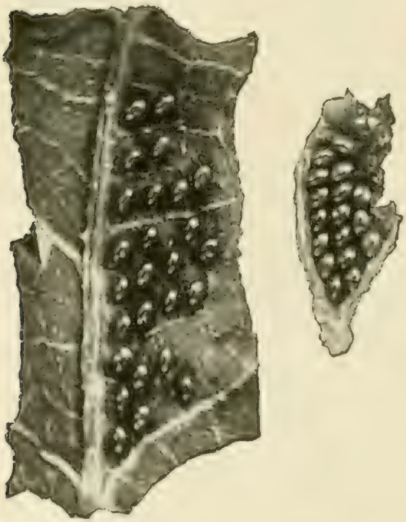


FIG. 280.—Eggs of the squash-bug enlarged. (Photo by R. I. Smith.)

Control. The eggs are easily seen and should be picked off and destroyed. The adults cannot be killed by insecticides, but

the nymphs may be destroyed by spraying with kerosene emulsion. The adult bugs may be readily trapped by placing small pieces of board or similar shelter near the vines, under which they will hide at night and from which they may be gathered in the early

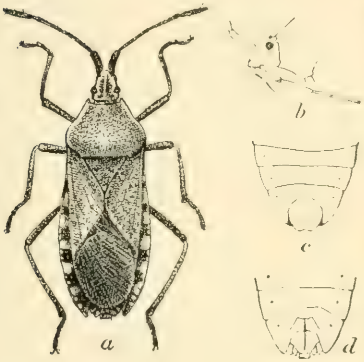


FIG. 281.—The squash-bug: *a*, mature female; *b*, side view of head showing beak; *c*, abdominal segments of male; *d*, same of female; *a*, twice natural size; *b*, *c*, *d*, more enlarged. (After Chittenden, U.S. Dept. Agr.)

FIG. 282.—The squash-bug: adult at left, and different stages of nymphs — about 1½ times natural size. (Photo by Quaintance.)

morning. Cucumbers and melons may be protected by planting early squash among them, as the bugs prefer the squash, from which they may be collected. Cleaning up the vines in the fall is evidently of importance in reducing the number which will hibernate.

The Squash Ladybird *

Although almost all of the ladybird beetles are exceedingly beneficial, this species, with its near relative the bean-ladybird (page 315,) are the exceptions which prove the rule, being the only

* *Epilachna borealis* Fab. Family *Coccinellidæ.* See F. H. Chittenden, Bulletin 19, n. s., Div. Ent., U. S. Dept. Agr.; J. B. Smith, Bulletin 94, N. J. Agr. Exp. Sta.

injurious forms with which we have to contend. Both the beetles and larvæ feed on the foliage of various cucurbs, but prefer that of the squash. It is an Eastern species, not being injurious west of the Mississippi and being most troublesome in the Middle Atlantic States. The beetle is nearly hemispherical in shape, slightly oval, about one-third inch long, yellowish or reddish-brown, marked with seven black spots on each wing-cover and four smaller ones on the thorax as shown in Fig. 283.

Life History. The life-history, as given by Dr. Chittenden for the District of Columbia and northward, is as follows: "The

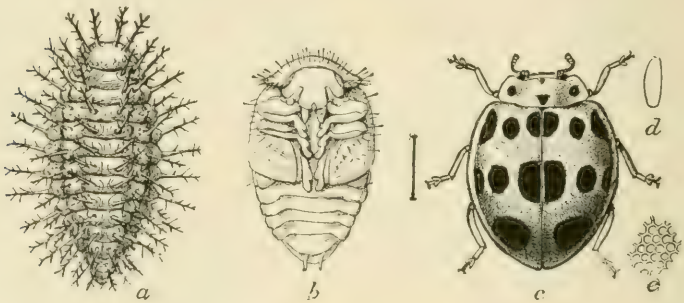


FIG. 283.—The squash ladybird (*Epilachne borealis* Fab.): *a*, larva; *b*, pupa; *c*, adult beetle—three times natural size; *d*, egg—four times natural size; *e*, surface of egg highly magnified. (After Chittenden, U. S. Dept. Agr.)

insect hibernates in the adult condition under bark or other convenient shelter and appears abroad sometime in May or June. Egg deposition has been observed in the latter part of June, and there is evidence that the eggs are deposited also much later." The eggs are about three-tenths inch long, elongate-oval, of a yellow color, and laid in irregular clusters of from 12 to 50. "They hatch in from six to nine days, and the larvæ begin to feed at once on the leaves, causing them to wither and die." The larva is yellow, with six rows of black branching spines, and is about one-half inch long when grown. "The larva attains full development in from two to four weeks, ceases feeding, and attaches

itself by its anal extremity to a leaf, and next day sheds its larval skin, which is pushed down toward the end of the body, when the pupa stage is assumed. The la:va matures anytime from the middle of July to near the middle of September. In the pupa state the insect remains from six to nine days, when the skin separates down the back and the perfect beetle emerges, the new brood appearing as early as the last of July. After feeding for some time the beetles disappear for hibernation, . . . beginning about the middle of September." The adults have the habit of marking out a circular area of the leaf, which seems to cause the tissue to wilt, and then feeding within this area. The larvæ are to be found feeding on the under surface of the foliage in July and August.

FIG. 284.—Work of the squash lady-bird—greatly reduced. (After W. E. Britton.)

Control.—Usually hand picking the beetles and eggs will control the pest, but if abundant it may be readily destroyed by spraying or dusting with arsenicals.

The Squash-vine Borer *

In many localities the most serious pest of squash is the Squash-vine Borer, and although other cucurbs are sometimes injured, they are relatively free from attack if squash or pumpkins are present. The larvæ bore in the stems, causing them to rot

* *Melittia satyriniformis* Hbn. Family *Sesiidæ*. See Circular 38, Bureau of Entomology, U. S. Dept. Agr.

where affected, so that they break off and the plant wilts and dies. The presence of the borer is indicated by the coarse yellowish excrement which it forces from its burrow and which is found on the ground beneath, and by the sudden wilting of the leaves. Injury is most severe at the base of the vine, which gradually decays, so that it is severed and the whole plant dies. A half-dozen or more larvæ are often found in a single stem, and as many as forty have been taken from one vine, the larvæ attacking all

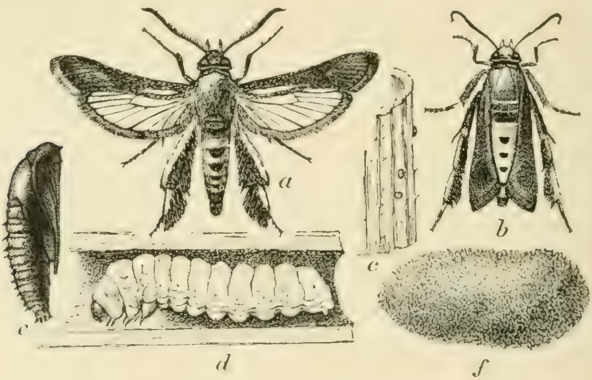


Fig. 285.—The squash-vine borer (*Melittia satyriniformis* Hbn.): *a*, male moth; *b*, female with wings folded at rest; *c*, eggs shown on bit of stem; *d*, full-grown larva in vine; *e*, pupa; *f*, pupal cell—all one-third larger than natural size. (After Chittenden, U. S. Dept. Agr.)

parts of the vine and even the petioles and large ribs of the leaves when abundant. Injury is worst on Hubbard, marrow, cymlings and late varieties of squash.

The adult is one of the clear-winged moths with a wing expanse of about 1¼ inches, the fore-wings being opaque, dark olive-green in color, with a metallic lustre and a fringe of brownish black. The hind wings are transparent, with a bluish reflection, and the veins and marginal fringe black. The abdomen is marked with orange, or red, black and bronze, and the legs are bright orange, with tarsi black with white bands. The species occurs throughout the States east of the Rockies and southward into Central and South America.

Life History.—The moths appear soon after their food-plants start growth, from mid-April along the Gulf Coast to June 1st, in New Jersey, and late June or early July in Connecticut. They fly only in the daytime, and their clear wings and brightly marked bodies give them a close resemblance to large wasps. The eggs are laid on all parts of the plant, but chiefly on the stems, particularly near the base. The oval egg is of a dull red color and about one-twenty-fifth inch long. The moth deposits her

FIG. 286. A squash stem cut open showing borers within. (Photo by Quaintance.)

eggs singly, and one individual has been observed to lay as many as 212. They hatch in one or two weeks. The young larva enters the main stem and tunnels through it, and often enters the leaf-petioles branching from it. It is a soft, stout, whitish caterpillar, with a small black head, and about one inch long when full grown. The larvæ reach maturity in about four weeks and then enter the earth, where they make tough silken cocoons, coated with particles of earth, an inch or two below the surface. In the South the larvæ transform to pupæ from which a second generation

of moths emerges in late July, but in the North the larvæ hibernate in the cocoons over winter, and transform the next spring. The pupa is about five-eighths inch long, dark brown, and with a horn-like process on the head between the eyes. By the aid of this the pupa cuts open one end of the cocoon and with the hook-like spines on the abdomen wriggles to the surface of the earth before transforming to the moth. As indicated, there is but one generation in the North, a partial second brood in the latitude of New Jersey and the District of Columbia, and two full generations in the South.

Control.—As the larvæ work within the vines, insecticide treatment is useless, and the pest must be controlled by methods of culture.

Obviously the vines should be raked up and destroyed as soon as the crop is gathered, so as to destroy all of the borers within them. As the larvæ or pupæ hibernate over winter in the soil, it has been found that frequent light harrowing in the fall will bring them to the surface, and that deep plowing in the early spring will then bury any surviving so that the moths cannot emerge. Rotation of the crop will evidently decrease the number of moths. Where the pest is abundant late squash may be protected by planting rows of early summer squashes as soon as possible. These will attract the moths so that there will be relatively few eggs deposited on the main crop planted later. As soon as the early crop is gathered, or as soon as it becomes well infested, if it is used only for a trap, the vines should be raked up and burned so as to destroy all eggs and larvæ. It is well to cover the vines with earth one or two feet from the base so as to induce the growth of secondary roots, which will support the plant in case the vine is severed lower down. The old-fashioned method of slitting the vines with a knife and thus killing the borers is about the only means of destroying them after they have become established. The position of a borer may be detected by the excrement extruded from its burrow, and if the wound be covered with moist earth it will assist the healing.

The Pickle Worm *

The pickle worm is so called because it was first noted as injuring cucumbers grown for pickling, but in the Gulf States, where it is most injurious it is more commonly a pest of melons, and, with the following species, with which it is often confused, is often known as the "melon worm." Injury in the Middle States occurs only periodically, though it has been noted in Illinois and southern Michigan, but in the Gulf States it is always a serious pest of all the cucurbs, destroying the blossoms, mining the stems, and boring into the ripening fruit.

The moth has a wing expanse of about 1¼ inches, is yellowish-brown with a purplish iridescence, and is readily recognized by an irregular yellowish transparent spot on the middle of the fore-wings, and the basal half of the hind-wings of the same color. The abdomen terminates in a conspicuous brush of large blackish scales.

Life History.—The moths emerge in late spring and deposit the eggs either singly or in clusters of 3 to 8 on the flowers, buds, or tender terminals. The yellowish-white egg is about one-thirtieth inch long, and rather elliptical. The first larvæ are to be found in Georgia by the middle of June. The young larvæ which hatch from eggs laid on the terminals bore into stems and leaves and later often tunnel out the vines like the squash-vine borer. Those from eggs laid on the blossoms usually feed in the blossoms, and a half-dozen may often be found feeding in single squash blossoms, for which they seem to have a decided preference. As they grow older the larvæ wander from one plant to another, often boring into several fruits. The older larvæ bore into the fruit, the excrement being pushed out from the orifice and later accumulating in the cavity within. A single larva boring into the rind will do sufficient injury to start decay and ruin the fruit, and often a

* *Diaphania nitidalis* Cramer. Family *Pyraustidæ*. See A. L. Quaintance, Bulletin 54, Geo. Agr. Exp. Sta., R. I. Smith, Bulletin 214, N. C. Agr. Exp. Sta.

half-dozen or more will be found in a single melon. Until half grown the larvæ are marked with transverse rows of black spots. The full-grown larva is about three-quarters inch long,

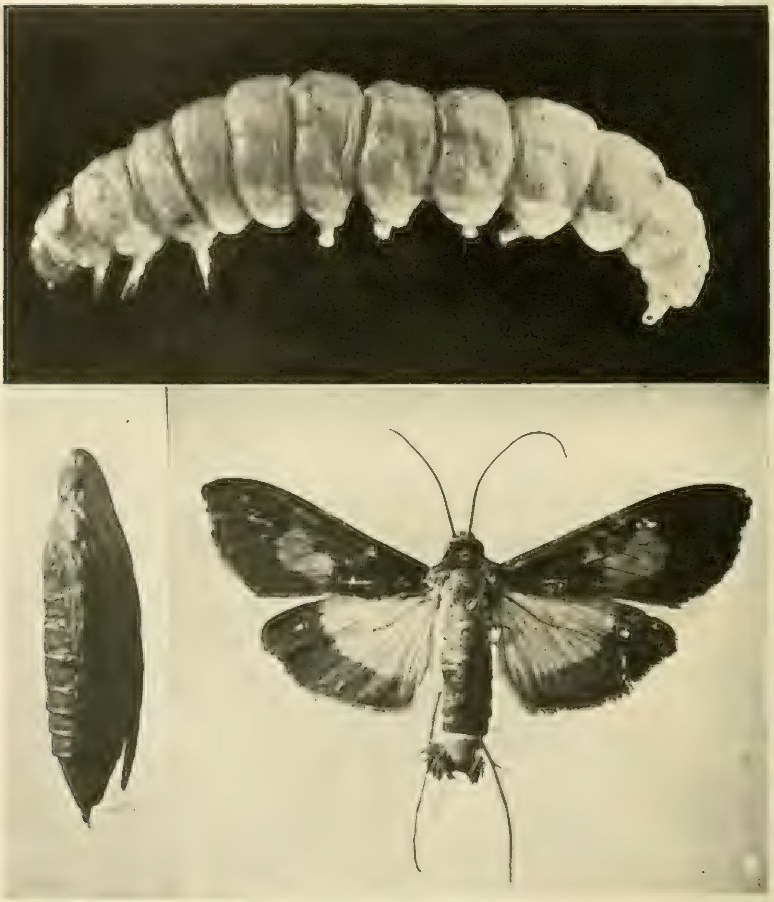


FIG. 287.—The pickle worm (*Diaphania nitidalis* Cramer): larva, pupa, and adult—all enlarged. (Photos by Quaintance.)

greenish or yellowish-green, with head and prothoracic shield brown. The larva reaches maturity in about two weeks, when a thin silken cocoon is made in the fold of a leaf in which the

pupal stage is assumed, which occupies about a week. The pupa is one-half to one inch long, brown, with wing and leg sheaths lighter, and the tip of the abdomen bears a group of short curved spines which hold the pupa more securely in the cocoon. During July and August the complete life cycle requires about four weeks in Georgia, and at least three definite generations have been recognized, the injury by the larvæ being most severe in July and August, evidently by the second generation. The winter is passed in the pupal stage in the foliage or trash remaining on the field.

Fig. 288.—Squash flower infested with pickle worms. (Photo by Quaintance.)

Control.—As injury is worst in late summer, early plantings and early-maturing varieties are but little injured. The thorough destruction of the vines, foliage, and trash on the field after the crop is secured is of the utmost importance in controlling this as well as other pests of cucurbs, and may probably be accomplished with this species by deeply plowing under the refuse. Professor A. L. Quaintance, to whom we are indebted for our knowledge of this pest, has found that the moths greatly prefer to oviposit on squash and that it may be successfully used as a trap-crop for the protection of other cucurbs. Rows of summer squash should be planted through the cucumber or melon fields as early as possible, the rows being planted every two weeks so there will be flowers through July. The squash bloom, with the contained larvæ, must be collected and destroyed at frequent

intervals. Otherwise the squash will merely augment the injury, as the larvæ will migrate to the crop. Careful tests of this method showed almost complete protection to muskmelons. The use of

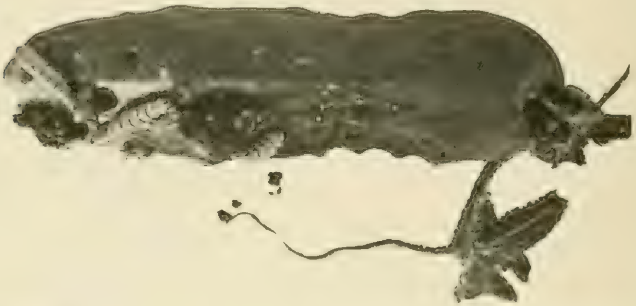


FIG. 289 —Pickle worms at work on a cucumber. (Photo by Quaintance.)

arsenicals has been of little value against this pest as far as tested, but as they should be applied to control the next species, may be of some incidental value.

The Melon Caterpillar *

This species is very similar to the last in life history and habits and is very commonly confused with it. It seems to be injurious only in the Gulf States, though the moths have been taken from Canada to Central America. The moth is a beautiful insect with wings of a pearly iridescent whiteness, bordered with brownish-black and expanding about an inch. The anterior half of the thorax and head is the same color as the wing border, while the abdomen is white, tinged with brownish toward the tip, which is surmounted by a brush of long dark scales. The larvæ are very similar to those of the pickle worm, and the life history so far as ascertained seems to be practically the same. The essential differ-

* *Diaphania hyalinita* Linn. Family *Pyraustidæ*. See A. L. Quaintance, Bulletin 45, Geo. Agr. Exp. Sta., p. 42; R. I. Smith, Bulletin 214, N. C. Agr. Exp. Sta.

ence in the habits of this species is that the young larvæ very commonly feed on the foliage. Later on they mine into the stems and fruit and are readily confused with those of the last species.

Fig. 290. — The melon-worm moth (*Diaphania hyalinita* Linn.)— enlarged. (Photo by Quaintance.)

Control.—The fact that the young larvæ feed on the foliage makes it possible to destroy them with arsenicals, and by spraying the young foliage with arsenate of lead 3 pounds to the barrel, as advised for the striped cucumber-beetle, they should be readily controlled. The cultural methods advised for the control of the last species will of course be equally applicable for this.

Fig. 291.—The melon-worm—enlarged. (Photo by R. I. Smith.)

CHAPTER XX

MISCELLANEOUS GARDEN INSECTS

The Pale-striped Flea-beetle *

Enormous numbers of the Pale-striped Flea-beetles often appear in late June or early July and nearly ruin the young crops they may attack before being brought under control. Such outbreaks occur only periodically, so that usually the grower is unprepared to cope with them, which is true of the appearance of many

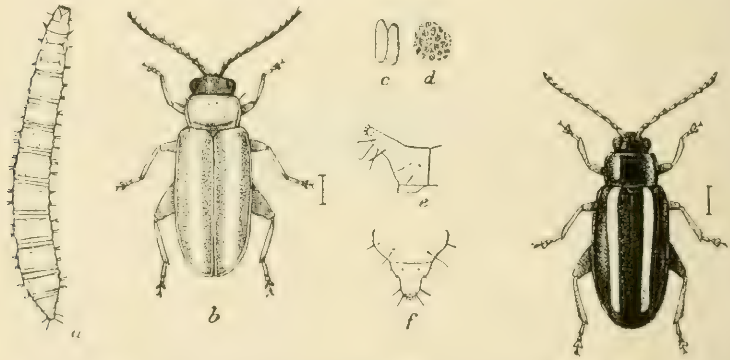


Fig. 292.—The pale-striped flea-beetle (*Systena blanda* Mels.): *a*, larva; *b*, beetle; *c*, eggs; *d*, sculpture of egg; *e*, anal segment of larva from side; *f*, s me from above; *a*, *d*, six times natural size; *e*, *f*, more enlarged; *g*, the banded flea-beetle (*Systena tæniata* Say)—six times natural size. (After Chittenden, U. S. Dept. Agr.)

of our worst insect pests. These flea-beetles are almost omnivorous as regards food, for although particularly injurious to corn and tomatoes, they have also injured beans, beets, potatoes, egg-plant, carrots, melons and other cucurbs, turnips and other crucifers,

* *Systena blanda* Mels. Family *Chrysomelidæ*. See F. H. Chittenden, Bulletin 23, n.s., Div. Ent., U. S. Dept. Agr., p. 22; S. A. Forbes, 18th Report State Ent. Ill., p. 21.

strawberry, cotton, oats, peanuts, pear foliage, etc., and many common weeds, so that it may be safely said that when abundant they will attack almost any crop at hand. The species seems to occur practically throughout the United States, but injury has been most common in the Middle States east of the plains.

The beetle is about one-eighth inch long, cream-colored, with the wing-covers marked with three stripes of dull light-brown, and the eyes and abdomen are black. A nearly related species, the banded flea-beetle,* is very similar in appearance, the dark stripes being expanded until it is a polished black with two white stripes (Fig. 292 *b*), and the two species have until recently been commonly considered as identical. They are similar in life history and habits so far as known, and may be considered as the same for practical purposes.

Life History.—Very little is known of the life history. The beetles usually appear in late June and early July, coming out in enormous numbers, gnawing small holes in the foliage of the plants attacked, so that when abundant they completely defoliate the plant in two or three days and often necessitate replanting. Dr. Chittenden has observed the eggs, which were deposited in the District of Columbia from June 10th to July 8th. The egg is elliptical, about one-fortieth inch long, and light buff-yellow in color. The larvæ feed on the roots of various common-weeds, including lambsquarter and Jamestown weed. They were observed to be full grown by the middle of May in central Illinois and pupated May 26th, from which beetles emerged June 17th. The larva is a whitish, slender grub much like those of other flea-beetles. It is about one-eighth inch long when full grown, with light-brown head, and the anal segment tapers to a conspicuous prolonged process, surmounted at the apex by a number of stiff, spiny hairs. From the data recorded it would seem probable that the insect winters in the larval stage on the roots of various weeds and develops to the adult in early summer when the eggs are laid. There seems to be no direct evidence of a second generation.

* *Systena tæniata* Say.

Control.—The destruction of the weeds on which the larvæ develop is of obvious importance, and it would be well to plow under deeply any fields grown up in weeds during late summer. Bordeaux mixture is possibly the best repellant for these beetles, though they will be driven off by covering the plants with any dust which thoroughly coats the foliage. Usually the best method will be to spray the plants thoroughly with Bordeaux mixture containing 3 pounds of arsenate of lead or one-third pound Paris green per barrel. All parts of the foliage must be thoroughly coated. Good success has also attended dusting the plants with Paris green and flour and by spraying the beetles with kerosene emulsion. Powdered arsenate of lead dusted over the foliage while the dew is on would probably prove effective, or it might be sprayed at the rate of 3 to 5 pounds to the barrel.

The Tarnished Plant-bug *

The tarnished plant-bug is one of the most common and troublesome plant-bugs throughout the country from Canada to Mexico. Seemingly it is nearly omnivorous, as it attacks almost all of the common garden crops, small fruits, tender shoots of fruit trees and young nursery trees, many flowering plants, and most of our common weeds. Both nymphs and adults injure the plants by sucking out the juices, and on many plants a small black spot appears where the insect has been feeding, which causes a deformation of the stem or leaf, as in the "buttoning" of strawberries, or tends to "blight" the terminal as in the case of dahlias, potatoes, and similar crops.

The adult is nearly one-quarter inch long, of a brassy-brown color, marked with black and yellow, and the thorax with red. The color and markings are quite variable. The nymphs feed upon the same plants as the adults and pass through four stages, shown in Fig. 293. The first stage is only one-twentieth inch long and yellowish or yellowish-green. The second stage

* *Lygus pratensis* Linn. Family *Capsidæ*. See Stedman, Bulletin 47. Missouri Agr. Exp. Sta.

is about twice as large, and similarly colored, except that there are two pairs of dark spots on the thorax and one on the middle of the third abdominal segment, which grow more distinct in the last two stages. With the third stage the small wing pads become visible and in the fourth stage they extend halfway down the abdomen.

Life History.—The adults hibernate over winter under any shelter available, such as the trash on affected fields, under leaves, boards, stones, etc., and emerge in early spring. The eggs are laid in Missouri in April. But little is known of the

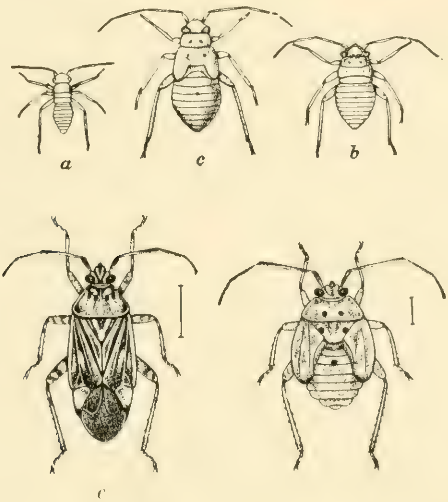


Fig. 293.—The tarnished plant-bug (*Lygus pratensis* Linn.): *a, b, c, d,* four stages of nymphs; *e*, adult bug—all about four times natural size. (After Forbes and Chittenden, U. S. Dept. Agr.)

places of oviposition, except that Taylor * has shown that sometimes apples are severely dimpled by the egg punctures. It is evident, therefore, that the eggs are inserted in the stems or leaves of the food-plants. The pale yellow egg is about one-thirtieth inch long, oval, elongate, and flared at the outer end, so as to be somewhat bottle-shaped. The first generation becomes full grown in about a month, after which all stages

* See E. P. Taylor, Journal of Economic Entomology, Vol. I, p. 370.

may be found feeding together until September or October. In southern Missouri Professor Stedman states that there are three generations, while in northern Missouri only two, but the exact number has not been carefully determined.

Control.—This is an exceedingly difficult insect to control, owing to the large number of food-plants and the fact that the adult takes wing and flies off quickly upon the least disturbance. As it sucks its food, arsenical insecticides are of course useless, and some contact insecticide must be used with which the insect may be hit. The nymphs may be sprayed at any time, but to hit the adult bugs they must be sprayed in early morning, while still sluggish. Spraying will be profitable where the nymphs are abundant, but it is doubtful whether it will be found a satisfactory means of combating the adults. Ten per cent kerosene emulsion and tobacco extracts have been used successfully. Where they are abundant the adults may be collected in considerable numbers by sweeping the foliage in early morning with a strong insect net and then dropping them into kerosene. Clean culture, including the destruction of all weeds, and such vegetation or trash as may furnish hibernating quarters, are important, as it is observed that injury is always worse where weeds have been allowed to multiply and the ground has been covered with weeds and trash.

The Garden Webworm *

The term garden webworm is possibly a misnomer, for although these little caterpillars frequently do more or less injury to various garden crops when they become overabundant and migrate to them from the weeds on which they normally feed, and occasionally do some damage to sugar beets, they are best known as a pest of corn and cotton. Though the species occurs throughout the United States and south to South America, it has been most injurious from Nebraska southward and east to Mississippi and

* *Loxostege similalis* Gn. Family *Pyraustidæ.* See C. V. Riley, Report U. S. Comm. Agr. for 1885, p. 265; Sanderson, Bulletin 57, Bureau of Entomology, U. S. Dept. Agr., p. 11.

Illinois. The larvæ feed normally on the pigweed or careless weed (*Amaranthus* spp.) from which they sometimes receive the local name of "careless worm," and only when they become overabundant on these weeds do they usually increase sufficiently to migrate from them and attack crops.

The moth is a yellowish, buff or grayish-brown color, marked as shown in Fig. 294, and with a wing expanse of about three-quarters of an inch. The larva also varies in color from pale and greenish-yellow to dark yellow, and is marked with numerous black tubercles as shown in Fig. 294, *b*, *c*.

Life History.—The hibernating habits are not known, but from analogy with the beet webworm, and the appearance of the

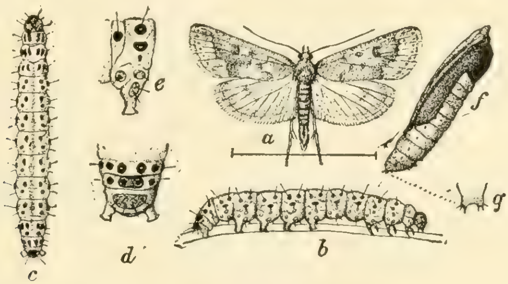


FIG. 294.—The garden webworm (*Loxostege similalis* Gn.): *a*, male moth; *b*, *c*, larvæ; *d*, anal segment of same; *e*, abdominal segment of same from side; *f*, pupa; *g*, tip of abdomen of same; *a*, *b*, *c*, *f*, somewhat enlarged; *d*, *e*, *g*, more enlarged. (After Riley and Chittenden, U. S. Dept. Agr.)

moths, it seems probable that the winter is passed by the larvæ or pupæ in the soil. The moths appear in Texas by mid-April and in Central Illinois in late May and early June. The yellowish eggs are laid on the foliage in small patches of from 8 to 20 and in Texas hatch in three or four days. The larvæ of the first generations feed on weeds or alfalfa, where it is grown, and then migrate to corn and cotton or garden truck, the former crops being attacked when six or eight inches high. In feeding the caterpillars spin a fine web, which gradually envelops the plant, of which nothing is left but the skeletons of the leaves when the larvæ are abundant. The larvæ become full grown in about three weeks in summer, when they descend to the soil and pupate

in small silken cells on or just below the surface. The moths emerge about eight days later, so that in midsummer the complete life cycle occupies about a month. In Texas there are probably five generations a year, and in Nebraska and Illinois three or four generations.

Control.—The plowing of infested land in late fall or winter, or thorough disking of alfalfa will be found to largely control the pest. Where it appears on cultivated crops it may be readily destroyed by at once spraying or dusting with Paris green or arsenate of lead. The destruction of the weeds upon which it feeds is obviously important in preventing the undue multiplication of the pest.

The Rhubarb Curculio *

Rhubarb is but little troubled with insect pests, but occasionally the stalks are found with numerous punctures from which the

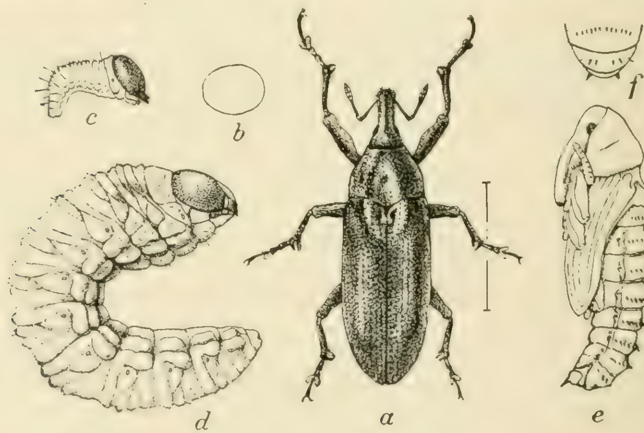


Fig. 295.—The rhubarb curculio (*Lixus concavus* Say): *a*, beetle; *b*, egg; *c*, newly hatched larva; *d*, full grown larva; *e*, pupa; *f*, back view of last abdominal segment of pupa—all about twice natural size. (After Chittenden, U. S. Dept. Agr.)

juice exudes. This has been caused by the feeding and oviposition of a large rusty-brown snout-beetle, which is usually

* *Lixus concavus* Say. Family *Curculionidæ.* See F. H. Chittenden, Bulletin 23, n. s., Division of Entomology, p. 61.

found on the affected plants. It is about three-quarters inch long, and will be readily recognized from Fig. 295. The beetles hibernate over winter and feed on dock, in the stalks of which the eggs are laid in May. Although eggs are laid in rhubarb, they fail to hatch or the young larvæ die. The grubs become full grown by midsummer and the beetles emerge in late summer and feed a little before entering hibernation.

Control.—As the beetles are sluggish and readily found, they may be easily destroyed by handpicking. Dock plants near the rhubarb patch should be pulled amd destroyed in early summer after the beetles have finished laying their eggs.

The Celery or Greenhouse Leaf-tyer *

This little caterpillar has become known as the celery leaf-tyer, for although it damages cabbage, beets, tobacco, lettuce, cauliflower, parsley, cucumber, sweet pea, and strawberry, it has been specially injurious to celery. It is equally well known as the greenhouse leaf-tyer, for it is one of the worst insect enemies of the florist, attacking violet, rose, chrysanthemum, carnation, and other greenhouse plants. On celery the larvæ both bore in the stems and web up the foliage upon which they feed upon the surface, skeletonizing the leaves. The usual method of feeding, to which is due the common name, is to fasten together two contiguous leaves, to curl over the edge of a single leaf, or to spin a thin silken web within which to feed.

The moth resembles that of the garden webworm, having a wing expanse of about three-quarters of an inch, the fore-wings being light clay-brown, suffused with reddish or ochreous brown and marked with blackish cross-lines as shown in the illustration, and the hind-wings are gray with darker margins. The full-grown larva is about three-quarters inch long and of a translucent greenish-white color. Down the middle of the back

* *Phlyctœnia rubigalis* Guen. Family *Pyralidæ*. See F. H. Chittenden, Bulletin 27, n. s., Div. Ent., U. S. Dept. Agr.; M. V. Slingerland, Bulletin 190, Cornell Univ. Agr. Exp. Sta., p. 159.

is a narrow green stripe, which is bordered on either side by a wider greenish-white stripe. The head is dark straw color, mottled with darker, often purplish dots. The species is widely distributed, occurring in practically all parts of the United States, and may be readily introduced into greenhouses upon plants.

Life History.—The eggs are very much flattened, translucent, broadly oval disks about one thirty-second inch long, laid in clusters of from eight to twelve, several often overlapping. The eggs hatch in from five to twenty days, according to the temperature. The larvæ feed mostly at night and become full grown in from

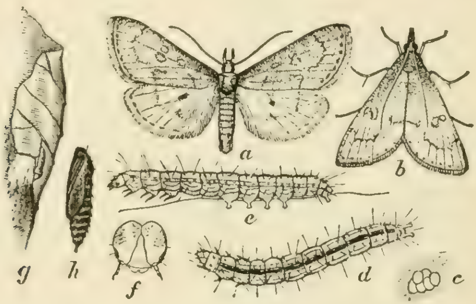


Fig. 296.—The celery leaf-tyer (*Phlyctænia rubigalis* Hbn.): *a*, moth; *b*, same in natural position at rest; *c*, egg mass; *d*, larva from above; *e*, same from side; *f*, head of same; *g*, pupa case; *h*, chrysalis—one-half larger than natural size except *c*, which is twice natural size, and *f*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

three to five weeks. They transform to pupæ within the webs which they have formed between the leaves, and the moths emerge one or two weeks later. The number of generations which occur out of doors and the method of hibernation have not been determined, but there are probably at least three generations in the open, while the number in greenhouses will depend upon the temperature and the food available.

Control.—No very thorough experiments in the practical control of the pest on field crops seem to have been made. A thorough application of arsenate of lead as soon as the young larvæ are noticed and before they have webbed the foliage badly would

doubtless destroy them, but after they have become established in their webs, handpicking will probably be the only effective remedy on such a crop as celery.

The Celery Caterpillar *

Everyone who grows celery, parsley or carrots is familiar with the large black-striped green caterpillar which feeds on their foliage, as it is probably the most common pest of those plants in all parts of the country, ragging the foliage and attacking the blossoms and undeveloped seeds. It is the larva of our most

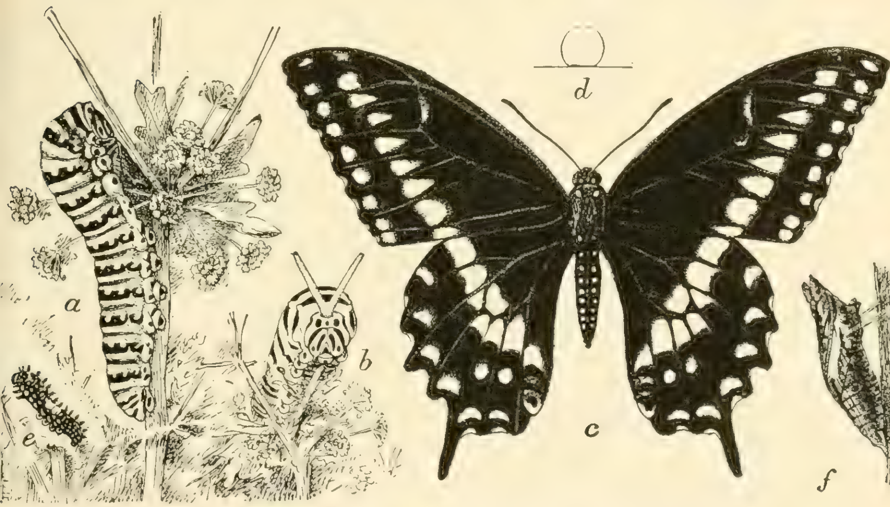


FIG. 297.—The celery caterpillar (*Papilio polyxenes* Fab.): *a*, full grown larva, side view; *b*, front view of head showing extended osmateria; *c*, male butterfly; *d*, egg; *e*, young larva; *f*, suspended chrysalis—about natural size except *d*. (After Chittenden, U. S. Dept. Agr.)

common black swallowtail butterfly, shown natural size in Fig. 297. The wings of the male are velvety black with bands of yellow spots. On the inner angle of the hind-wing is a well-marked eyespot, and the hind-wing terminates in a distinct "tail." The female is somewhat larger, the inner row of yellow spots is

* *Papilio polyxenes* Fab. Family *Papilionidæ*.

wanting, and the hind-wings are covered with pale-blue scales on the posterior half. There is considerable variation, however in the color of both sexes.

Life History. In the North the winter is passed in the chrysalis stage and the butterflies appear in May in New England, while in the far South the butterflies hibernate over winter and appear in March or April. The eggs are laid on the foliage and are of globular form, about one-twenty-fifth inch in diameter, at first pale honey-yellow, but later reddish-brown. The eggs hatch in from four to nine days. The young larvæ are quite dissimilar from the older stages, being nearly black with a white band around the middle of the body (Fig. 297, *c*). The larvæ feed exclusively on umbelliferous plants, including besides those mentioned, caraway, fennel, parsnip, dill, wild carrot, wild parsnip, and other weeds of this family. The full-grown larva is shown, natural size, in Fig. 297, *a*. It is bright green, sometimes yellowish, and marked with rings and spots of velvety black as illustrated. Just back of the prothorax is a pair of membranous yellow horns called osmateria, which give off a peculiar pungent odor, which is quite disagreeable and evidently aids in frightening away enemies. These osmateria are soft, retractile organs, which are drawn back between the segments and are extruded only when the larva is disturbed.

In the far South the larva will become grown in ten days, but in the North it requires three to four weeks. The caterpillar then attaches itself to some part of the plant by the anal prolegs, and fastens a strong loop of silk around the thorax, and sheds its skin, leaving the chrysalis or pupa firmly attached to the leaf or stem as shown in Fig. 297, *f*. The chrysalis is a dull gray color marked with black and brown and about 1¼ inches long. In from ten days to two weeks the butterfly emerges from the chrysalis. Thus the complete life cycle may be passed in twenty-two days in the South to eight weeks in the North. In the North there are but two generations a year, while in the South there are probably three or four.

Control.—The caterpillars are so readily seen, and if not seen

they soon reveal their presence by the peculiar odor when disturbed, that they may usually be picked off and crushed, and so rarely become sufficiently numerous to warrant other treatment. They may be readily controlled by spraying or dusting with arsenicals.

The Celery Looper *

This species is very closely related to the cabbage looper (page 361) and occurs throughout the Northern States east of the Rocky Mountains. According to Forbes and Hart it is more common than the cabbage looper in Illinois, where it is a serious pest of celery and has been reared on sugar-beet, but elsewhere it is not as common.

The moth has a wing expanse of about two inches, the forewings being purplish brown with darker shades of velvety brown

FIG. 298.—The celery looper (*Plusia simplex* Guen.): male moth and larva – somewhat enlarged. (After Chittenden, U. S. Dept. Agr.)

and with a prominent silvery white discal spot, while the hind wings are yellowish, strongly banded with dark fuscous. The caterpillar or larva is similar to that of the cabbage looper, but the spiracles are surrounded with black rings, while in the cabbage looper these rings are indistinct or wanting.

Forbes and Hart believe that there are three broods in a year. "The caterpillars of the first generation of the year hatch late in May and get their growth late in June or early in July. The life of the second generation extends from the first part of July to the

* *Plusia simplex* Guen. Family *Noctuidæ.* See Chittenden, Bulletin 33, Division of Entomology, U. S. Dept. Agr., p. 73.

middle of September, and the third begins to issue from the egg early in October. This brood hibernates about half grown, attaining full size during the latter part of April."

Control.—No accounts of experiments in control are on record, but doubtless the same measures as used against the cabbage looper will be found applicable.

The Carrot-beetle *

The carrot-beetle is a native species which has been particularly injurious to carrots along the Atlantic Coast from Long Island through the Gulf States. The species occurs, however, very generally throughout the country as far north as central Indiana, and on the Pacific coast. It has a considerable number of food-plants; in Louisiana and Mississippi it has injured the corn crop, the beetles cutting the corn just above the roots; in Illinois the beetles injured sunflowers and sweet potatoes; in Indiana they attacked carrots, celery and parsnips; in Texas they have injured potatoes and shrubs and vegetables of various kinds; and in Nebraska they have damaged sugar-beets.

Fig. 299.—The carrot-beetle (*Ligyrus gibbosus* Dej.) — much enlarged. (After Forbes.)

The damage is done entirely by the adult beetles, which are among the smaller of the May-beetles or June-bugs, measure one-half to five-eighths of an inch long, and are from reddish brown to nearly black in color. The beetles gouge into the roots or stems just below the surface of the soil, often ruining the root for market without injuring the top. The injury may occur by

* *Ligyrus gibbosus* Dej. Family *Scarabæidæ*. See F. H. Chittenden, Bulletin 33, n. s., Div. Ent., U. S. Dept. Agr., p. 32.

hibernated beetles in the spring from April to June or by newly transformed individuals in late summer or autumn.

The life history has not been studied, but is probably very similar to that of *Lachnosterna* (page 79).

Control.—No very satisfactory means of control have been tried in a practical way. It is stated that lime scattered over infested fields has driven the beetles away. It is evident that after the crop is gathered, infested fields should be pastured with hogs, if possible, or plowed deeply, and plowed again in the spring. Evidently further study of the habits of the pest is necessary before satisfactory means of control may be devised.

The Carrot Rust-fly *

The Carrot Rust-fly is a European species, being a serious pest of carrots in England and Germany, which has been known in Canada since 1885 and appeared in New York in 1901 and since then in New Hampshire. The larva or maggot which does the injury very much resembles the cheese maggot or skipper in general appearance, is a rather dark brown, and a little less than one-third inch long. The parent fly is about one-sixth inch long with a wing expanse of three-tenths inch, and is a dark blackish-green color, sparsely clothed with yellow hairs, and with pale yellow head and legs, except the eyes, which are black.

"Attack on carrots is not difficult of recognition. The leaves of the young plants early in the spring turn reddish, and the roots are found to be blotched with rusty patches, particularly toward their tips. The roots when stored for winter, although not always manifesting any degree of injury on the outer surface, may at times be perforated in all directions by dirty brownish burrows, from which the whitish or yellowish larvæ may be found sometimes projecting." Celery is also attacked, the larvæ eating the thick part of the root when it is half grown, stunting the plant so as to make it worthless for market. The life history of the species

* *Psila rosæ* Fab. See Chittenden, Bulletin 33, n. s., Division of Entomology, U. S. Dept. Agr., p. 26.

does not seem to have been carefully observed, but from analogy is probably somewhat similar to that of the cabbage root-maggot, except that the maggots of the carrot rust-fly develop and transform on carrots in storage if the temperature be sufficient.

Control.—Late sowing has been practiced to advantage, and the rotation of crops is of obvious importance, as is the deep plowing of infested land. Where carrots have been stored in earth, this earth into which the larvæ have entered and pupated should be

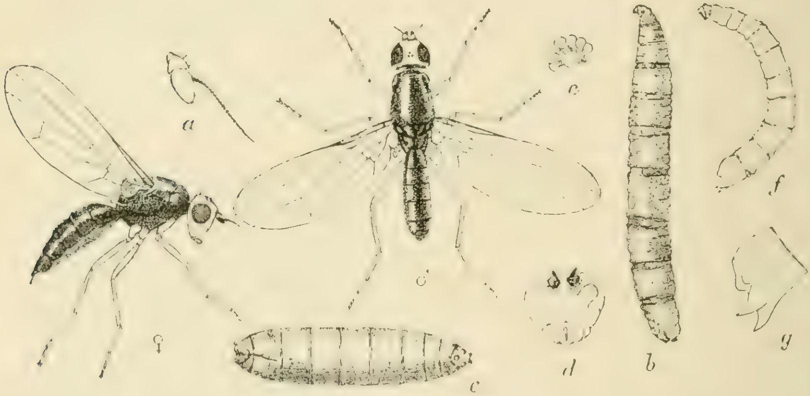


Fig. 300.—The carrot rust-fly (*Psila rosae* Fab.): ♂, male fly; ♀, female fly, side view; *a*, antenna of male; *b*, full-grown larva from side; *c*, spiracles of same; *a*, anal extremity from the end; *e*, puparium; *f*, young larva; *g*, anal segment from the side—eight times natural size except *a*, *c*, *d*, *g*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

treated, either by burying it deeply, spreading it out in thin layers on the surface, or throwing it into pools where it will be frozen. Kerosene emulsion, 1 part stock solution to 10 of water sprayed along the rows while the carrots are young, or sand, land plaster or ashes, to 3 gallons of which 1 pint of kerosene has been added, sprinkled along the rows, have been of some value in Canada. These should be applied three or four times, once a week after the roots begin to form, and particularly after the rows have been thinned.

The Parsnip Webworm *

The Parsnip Webworm is quite a common pest of the forming seed of the parsnip, but fortunately it seems to prefer wild carrot as a breeding plant. It is an imported species, occurring in northern Europe, which was first observed in this country in 1873 and since then has become generally distributed over the Northern States and Canada westward to the Mississippi.

The moth is a grayish-buff or pale ochreous color, marked with fuscous, the wings expanding about three-quarters of an inch. The larva is a pale yellowish, greenish or bluish-gray, with con-

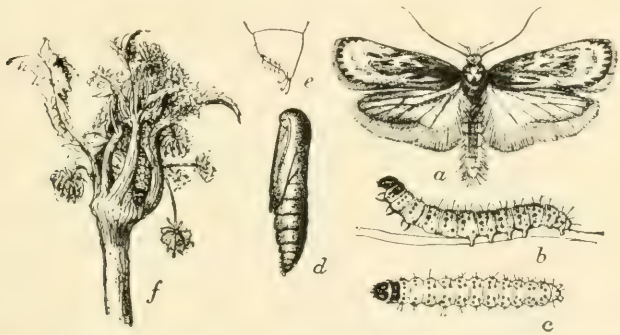


Fig. 301.—The parsnip webworm (*Depressaria heracliana* De G.): *a*, moth; *b*, *c*, larvæ; *d*, pupa; *e*, anal extremity of pupa; *f*, umbel of parsnip webbed together by the larvæ—natural size. (After Riley.)

spicuous black tubercles, the head and prothoracic shield black, and is about half an inch long when grown. The larvæ web the flower-heads together until they are contracted into masses of web and excrement as shown in the illustration. "After the larvæ have consumed the flowers and unripe seeds and become nearly full grown, they enter the hollow stems of the plant by burrowing their way inside, generally at the axils of the leaves, and then feed upon the soft, white lining of the interior. Here, inside the hollow stem, they change to the pupa state. The larvæ are

* *Depressaria heracliana* DeG. Family *Œcophoridæ*. See C. V. Riley, "Insect Life," Vol. I, p. 94.

moderately gregarious. They will sometimes eat newly sown parsnip after the older plants originally attacked have been destroyed, in such cases eating the tender green leaves, while of the older plants they eat only the flower-heads and interior lining of the stems." The moths appear in late July and early August.

Control.—Thorough spraying or dusting with arsenicals will destroy the caterpillars, according to Chittenden. If the flowers are destroyed before they are noticed, cut off and burn all infested stems before the moths emerge from the pupæ. Obviously it will be important to avoid planting parsnips in or near waste places which have grown up in wild carrot.

The Onion Thrips *

The small yellowish "thrips" which chafe the epidermis from the green leaves, causing them to dry out, whiten and die, have become well known to onion growers in practically all parts of the United States where onions are raised extensively. It is a European insect, occurring in Germany and Russia, and has also been imported into the Bermudas.

The adult thrips is about one-twenty-fifth of an inch long, of a pale yellow color, tinged with blackish. The general appearance, much enlarged, is shown in Fig. 302. The slender, elongate body bears two pairs of narrow, bristle-like wings which are of no value for flight. The fore-wing contains two wing-veins, and the hind-wing but one, the posterior margin of both bearing a fringe of long hairs. When at rest the wings lie together along the back.

The thrips belong to a quite distinct order of insects, the *Thysanoptera* (or *Physapoda*), species of which are commonly found in the flowers of the rose and clover. The mouth-parts are quite different from those of any other order of insects, being intermediate between those of biting and sucking insects, the

* *Thrips tabaci* Lind. Order *Thysanoptera*. See Quaintance, A. L., Bulletin 46, Fla. Agr. Exp. Sta., "The Strawberry Thrips and the Onion Thrips." Full account and Bibliography; Pergande, Th., "Insect Life," Vol. VII, pp. 292–295; Osborne-Mally, Bulletin 27, Iowa Agr. Exp. Sta., pp. 137–142; Sirrine, Bulletin 83 N. Y. Agr. Exp. Sta., pp. 680–683.

mandibles being reduced to bristle-like structures. Their manner of feeding does not seem to be clearly understood, though Professor Quaintance states that the onion thrips frequently rasps off and swallows pieces of leaf tissue. However, they are able to destroy the surface tissue of the leaf so that it wilts, and fields badly affected become blighted and white.

This species has quite a list of food-plants, cabbage and cauliflower often being considerably injured. Among them may be

FIG. 302.—The onion thrips (*Thrips tabaci* Lind.)—very greatly enlarged. (Photo by Quaintance.)

mentioned turnip, kale, sweet clover, squash, cucumber, melon, parsley, tomato, and several common garden flowers and weeds.

Life History.—The eggs are slightly less than $^1/_{100}$ of an inch long—too small to be visible to the unaided eye—elongate, and curved somewhat kidney-shaped. They are laid singly just beneath the surface of the leaf and hatch in about four days. The young nymphs resemble the adults in shape, but are at first almost transparent in color and then a greenish-yellow. They are frequently found feeding in small groups. Both the

young and adults have a pair of sharp spines at the tip of the abdomen which they use to drive away enemies by striking them quickly right and left. Two or three days after birth the skin is shed and another molt occurs five or six days later. With the third stage the wing-pads appear. This stage lasts four days, and during it the insects take no food and remain almost quiet, moving with difficulty. On onions the nymphs have been found mostly on the bulbs in the loose soil. With the next molt, the insect becomes mature and winged. Thus, the total life cycle as observed by Professor Quaintance in Florida is about sixteen days. In Russia Dr. Lindeman found that a generation required forty-seven days. "In Florida there are probably no distinct broods, as all stages may be found at the same time. Allowing for the life cycle at sixteen days, a large number of broods could occur during the year, but unfavorable conditions keep them reduced, except during the spring and perhaps early summer (the worst injury occurring in May and June), so that it will probably not happen that they will develop throughout a year according to their capabilities."

Control.—The pest may be successfully controlled by spraying with whale-oil soap, 1 pound to 2 gallons of water, rose-leaf insecticide, 1 pint to 4 gallons of water, or kerosene emulsion diluted 8 to 10 times. Tobacco decoction (see page 55) will probably prove equally effective, using it as strong as necessary. Probably 1 pound of stems to 2 gallons of water will be satisfactory. The spraying should be done very thoroughly so as to reach the insects in the axils of the leaves, and the soil around the plant also should be well wet to destroy the mature nymphs that may be hiding.

The Imported Onion-maggot *

The common white maggot which bores into the roots and bulbs causing them to wilt and decay, is probably the most important insect pest of the onion. The present species is by far the most commonly injurious and is termed "imported" because

* *Pegomyia ceparum* Bouché. Family *Anthomyiidæ*. See same references as for cabbage-maggot, footnote, page 347.

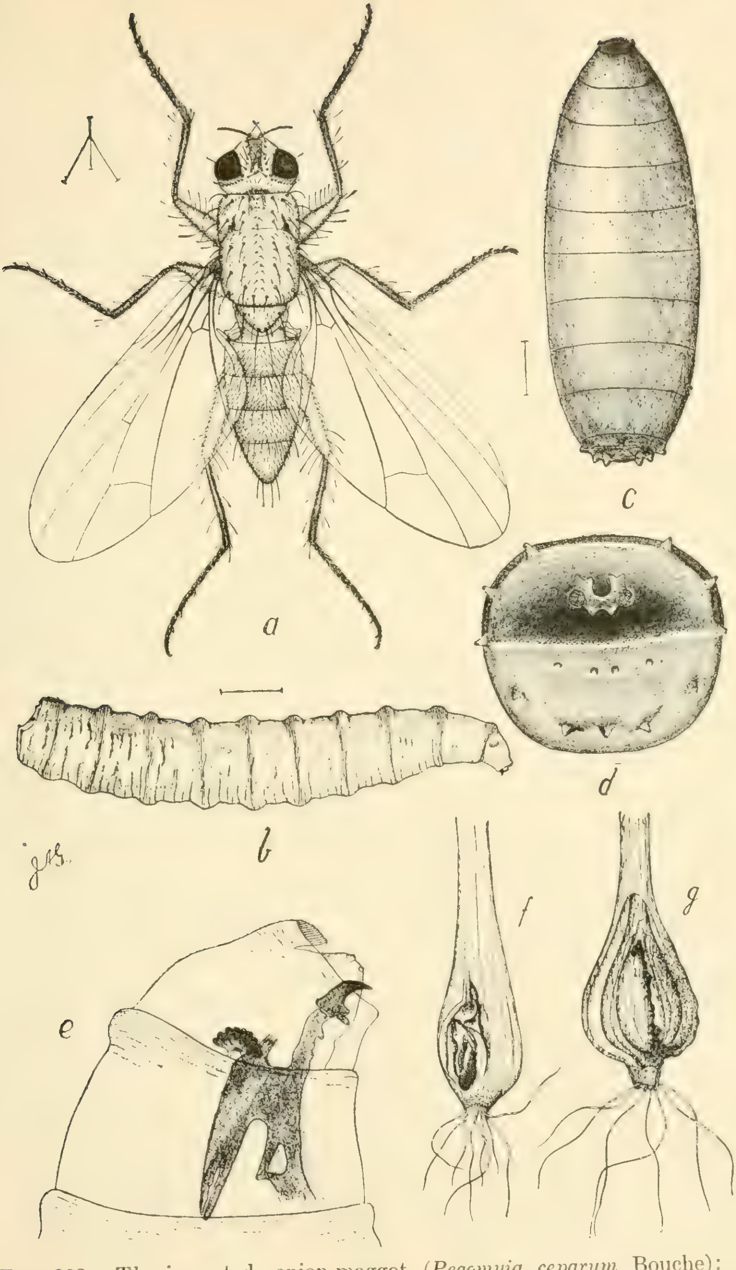


FIG. 303.—The imported onion-maggot (*Pegomyia ceparum* Bouche): *a*, adult; *b*, maggot; *c*, puparium; *d*, anal segment of maggot showing spiracles; *e*, head with mouth-parts—all very much enlarged; *f* and *g* show injury to young onions. (After J. B. Smith.)

it was early known as a pest in Europe and was imported into this country probably in colonial times.

These maggots are the offspring of small flies, somewhat resembling small houseflies and very similar to those of the cabbage root-maggot (see page 347).* The wings expand about three-eighths of an inch and the body is half that long. The male is gray with black bristles and hairs, the face is white with black hairs, there are three black lines between the wings, and the abdomen bears a row of black spots along the middle. The female is a little larger, inclined to dark yellowish, and with a yellowish face.

Life History.—The flies appear in the spring by the time young onions are up and the eggs are deposited in the sheath and in the axils of the leaves, from two to six being placed upon a plant. The eggs are just perceptible to the eye, white, oval, and about one-twenty-fifth of an inch long. The young maggot works its way down from the sheath to the root, upon which it feeds until it is consumed, only the outer skin remaining, and often cuts off the plant completely. Another plant is then attacked and often several young plants are consumed before the maggot is full grown. Later in the season the maggots bore into the bulbs, a number of maggots usually being found in a single bulb and their presence being indicated by a slimy mass of soil at the entrance of the cavity. If such bulbs are not killed outright, they usually rot in storage. The first presence of the pest is indicated by the wilting of the young plants, and by the central leaves of the older plants yellowing and dying.

The maggots become full grown about two weeks after hatching and are then about three-eighths of an inch long. They are dull white, with the jaws appearing beneath the skin as a short black stripe at the pointed end of the body. The posterior end of the body is obtuse and is cut off obliquely, the margin of the last segment bearing a number of tubercles by which this species may be distinguished from the cabbage-root maggot. (See Slingerland, l. c.).

* See Slingerland, Bulletin 78, Cornell Agr. Exp. Sta., p. 495, for characters distinguishing these two species.

The outer skin of the maggot now becomes hardened and within it the insect transforms to the pupa, which remains in the soil at the base of the plant for about two weeks, when the adult fly emerges. Two or three generations probably occur in the Northern States. Professor R. H. Pettit states that some of the flies hibernate while many of the pupæ remain in the soil over winter and the flies issue from them in the spring. This complicates remedial measures.

Control.—Liberal applications of commercial fertilizers such as nitrate of soda, which will assist to rapid growth, are of great value in overcoming injury by all root-feeding pests. Thorough culture is of value. Rotation of the onion plot to a point far distant from that of the previous year, the cleaning up of old beds, and plowing them deeply in the fall, will aid in the control. Pull up and destroy the young plants affected as soon as noticed, being careful to dig up the maggots with the roots. The application of carbolic emulsion as for the cabbage-root maggot has been advocated and will doubtless lessen the injury by repelling the adult flies. Concerning it see page 354. Apply early in the season and at intervals of a week.

The Barred-winged Onion-maggot *

The adult flies of this species may frequently be found upon corn and are readily recognized by the banded wings. They are similar in size to the last species, but the back is metallic blue-green except the head, which is mostly hoary, with brownish-black eyes. The maggots have been recorded as injurious to corn and sugarcane and have been recently noted in Michigan associated with the common onion-maggot, destroying onions.† The maggots are similar to the onion-maggot but the posterior end is more rounded and may be distinguished from the illustrations. The winter is passed in the puparium as far as observed.

Remedies.—In addition to the measures advocated for the last

* *Chætopsis ænea* Wied. Family *Anthomyidæ.*

† See Pettit, Bulletin 200, Mich. Agr. Exp. Sta., p. 206.

species, the destruction of the affected onions and the thorough plowing of affected land in the fall is of prime importance. Stored

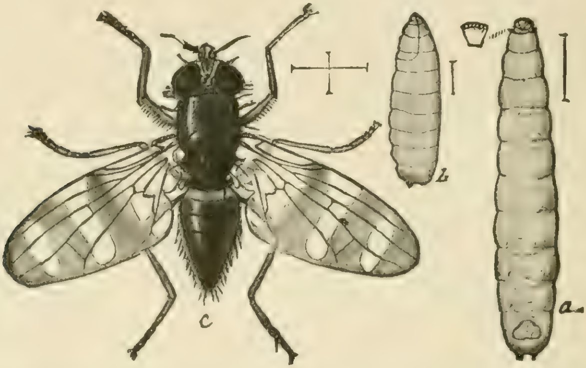


FIG. 304.—The barred-winged onion-maggot (*Chætopsis ænea* Wied.): *a*, larva, with spiracular opening highly magnified at left; *b*, puparium; *c*, adult fly—all enlarged. (After Riley and Howard, U. S. Dept. Agr.)

onions which prove infested may be fumigated with carbon bisulfide to destroy the maggots and puparia and prevent the emergence of the adults.

The Asparagus-beetle.*

This is a well-known pest of asparagus in Europe and was first observed in Queens County, New York, in 1862, where it threatened to destroy the asparagus, one of the most valued crops of the Long Island truckers. Since then it has gradually spread northward to southern New Hampshire, south to North Carolina, and west to Illinois and Wisconsin, and has been found at two points in California. There seems no reason why it should not spread to wherever asparagus is grown, at least in the Northern States.

The beetle is a handsome little creature about one-quarter inch long, blue-black in color, with red thorax, and dark blue wing-covers, marked with lemon-yellow and with reddish borders. The markings of the wing-covers are quite variable, the light color

* *Crioceris asparagi* Linn. Family *Chrysomelidæ*. See F. H. Chittenden, Yearbook, U. S. Dept. Agr., 1896, p. 341; Bulletin 66, Bureau of Ent., pp. 6, 93, and Circular 102, *Ibid.*

sometimes forming submarginal spots, while in other specimens it becomes so diffused as to form the principal color of the wing-covers.

Both adults and larvæ feed upon the tender asparagus shoots in the spring and later attack the fruiting plants. Their attacks render the shoots unfit for market and in many cases their injury has been so severe as to make it extremely difficult to establish new beds.

Life History.—The beetles hibernate over winter under whatever rubbish or shelter may be available near the asparagus patch.

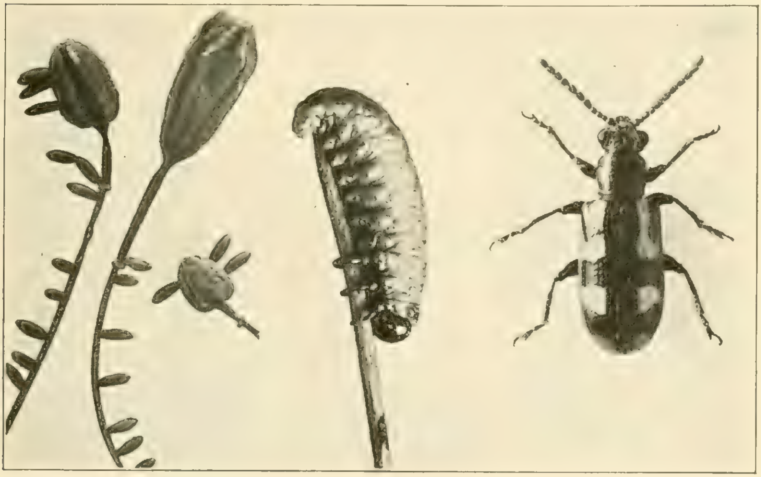


FIG. 305.—The asparagus-beetle (*Crioceris asparagi* Linn.): eggs, larva, and beetle—all much enlarged. (Photos by W. E. Britton.)

About the season that cutting asparagus for market commences they appear and lay the eggs for the first new brood. The egg is dark brown, oval, nearly one-sixteenth of an inch long and is laid on end. The eggs are deposited upon the stems or foliage, usually two to seven or more in a row. They hatch in from three to eight days. The young larvæ at once commence to attack the tender shoots, and later in the season feed upon the foliage. They become full grown in from ten days to two weeks. The full grown larva, as shown in the illustration, is about one-third of an inch long, soft

and fleshy, much wrinkled, and of a dark gray or olive color, with black head and legs. The mature larva drops to the ground and just beneath the surface forms a little rounded earth-covered cocoon within which it changes to the pupa, from which the beetle emerges in about a week. Thus the complete life cycle may be passed in a minimum of three weeks at Washington, D. C., where there are possibly four generations in a year, while further north, six or seven weeks may be required for the life cycle, and there are probably only two generations.

The asparagus-beetles are held in check by several natural agencies. Several species of ladybird-beetles feed upon the eggs, while numerous soldier-bugs attack the larvæ which they impale on their stout beaks. The adult beetles are often killed by low temperature in the winter, which doubtless limits their northern spread, while the eggs and larvæ are sometimes killed by the intense heat of summer, which will also probably limits the southern spread of the species.

Control.—One of the best means of control is to keep all shoots cut down in the spring so as to force the beetles to lay their eggs on the young shoots, which are cut for market every few days before the eggs have hatched, and hence no larvæ are allowed to hatch.

Another method which has proven effective is to cut down all the seed stems but a few rows here and there, so that the beetles will concentrate upon them, and then poison these thoroughly with arsenicals, or they may be cut down and burned and other rows allowed to grow as traps.

Air-slaked lime dusted on the plants in the morning while the dew is on will destroy the soft-bodied larvæ very effectively. Another way to destroy the larvæ in hot weather is to simply brush them from the plants so that they will drop on the hot soil. As they crawl but slowly few will regain the plants, particularly if the brushing be followed with a cultivator.

Probably the most effective means of controlling this pest, which was formerly a very difficult one to combat, is spraying with arsenate of lead. Use 3 pounds to 50 gallons, to which 3 pounds

of resin soap should be added to render it more adhesive, although good results have been secured without the sticker. Such spraying should be given as soon as cutting is over and should be repeated once or twice at intervals of ten days. Where the young shoots are kept closely cut and the bed is then sprayed, there should be no trouble to control the pest, and young beds should be kept thoroughly sprayed with arsenate of lead from the time the beetles appear until danger from injury is over.

The Twelve-spotted Asparagus-beetle *

The Twelve-spotted Asparagus Beetle is also of European origin, having been first introduced into this country near Baltimore, Md., in 1881. Since then it has become almost as widely distributed as the previous species.

The beetles may be distinguished from the last species by the broader wing-covers, each of which is orange-red, marked with six

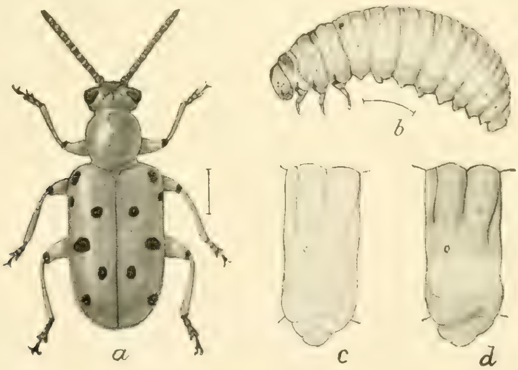


FIG. 306.—The twelve-spotted asparagus-beetle (*Crioceris* 12-*punctata* Linn.): *a*, beetle; *b*, larva; *c*, second abdominal segment of larva; *d*, same of *c*, *asparagi*—*a*, *b*, enlarged; *c*, *d*, more enlarged. (After Chittenden, U. S. Dept. Agr.)

black spots. The chief injury by this species is by the beetles which emerge from hibernation feeding on the young shoots. Later generations attack the foliage, but the larvæ seem to prefer to feed upon the ripening berries. The larva is of the same gen-

* *Crioceris* 12-punctata Linn. See F. H. Chittenden, l.c.

eral appearance as that of the preceding species, but may be distinguished by its orange color. The eggs are laid singly, and are attached on the sides instead of on end. They are deposited mostly on old plants toward the ends of the shoots which bear ripening berries lower down. Soon after a larva hatches it finds its way to a berry and feeds upon its ripening pulp, from which it migrates to another, feeding upon several, perhaps, before full growth is obtained, when it drops to the ground and pupates like the last species. The life cycle is essentially the same and there are probably the same number of generations.

Control.—The remedies advocated for the previous species will be found satisfactory except those which are directed against the larvæ, as the habit of the larva of concealing itself in the berry would make the application of insecticides to the seedstalks of little use.

The Asparagus Miner *

Occasionally injury by the small white maggots of a fly have been observed in the asparagus beds of Long Island, California, Pennsylvania, Massachusetts and District of Columbia, but the damage seems rarely to be very serious. The adult is a small black fly about one-sixth of an inch long and is usually found on the flowers of the asparagus, and occurs from New England to Tennessee. These flies emerge early in June. The exact manner of egg-laying has not been observed, but the young maggots are found mining just beneath the surface of the stalks, especially young stalks. The maggots are about one-fifth an inch long, pure white, except the black rasping hooks which project from the head. When full grown the maggots change to puparia beneath the epidermis. The next brood of adult flies emerge early in August. A second brood of maggots seems to occur and the puparia of the second brood pass the winter, and from them come the flies early the next summer.

* *Agromyza simplex* Loew. Family *Agromyzidæ*. See Sirrine, Bulletin 189, N. Y. Agr. Exp. Sta.; Chittenden, Bulletin 66, Part I, Bureau of Entomology, pp. 1 and 5, Fig. 2.

Injury from the mining of the maggots has been most serious on seedling and newly set beds, though it may occur on cutting beds, being apparent by the plants turning yellow and dying much earlier than they naturally do.

Pulling the old stalks and burning them in late summer seems

FIG. 307.—The asparagus miner (*Agromyza simplex* Loew): at left, side view of fly; *a*, larva; *b*, thoracic spiracles; *c*, anal spiracles; *d*, puparium from side; *e*, same from above; *f*, section of asparagus stalk showing injury and location of puparia on detached section—*a*, *e*, much enlarged; *f*, slightly reduced. (After Chittenden, U. S. Dept. Agr.)

to be the best means for controlling the pest from our present knowledge of it, which, however, is still rather meager. Dr. Chittenden has suggested that letting a few stalks grow as a trap-crop to which the flies might be lured, and then destroying these stalks, might protect the cutting beds.

CHAPTER XXI

INSECTS INJURIOUS TO THE SWEET POTATO *

The Sweet-potato Flea-beetle †

As soon as the sweet-potato plants are set out they are often attacked by hordes of hungry little brownish flea-beetles. Small channels are eaten out of both surfaces of the leaf in a very characteristic manner, quite different from the work of other flea-beetles (Fig. 309), and often the whole surface is seared but never punctured. As a result many of the leaves of the seedling are

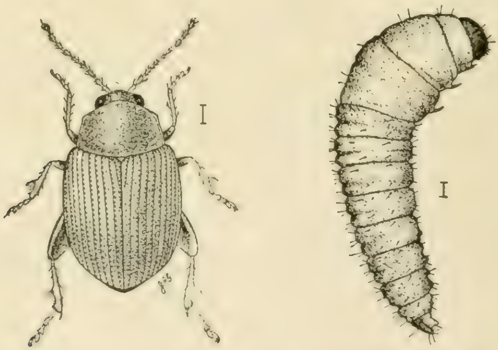


FIG. 308.—The sweet-potato flea-beetle (*Chætocnema confinis* Lec.): adult and larva—much enlarged. (After J. B. Smith.)

killed outright, turn brown, and decay, while new leaves put out from below, thus checking the growth. These attacks have been found to be worst on low land and that previously in sweet potatoes, and are always first noticed near fence rows or woodland where the beetles have hibernated. The beetle is bronzed or

* See Sanderson, Bulletin 59, Md. Agr. Exp. Sta.; J. B. Smith, Bulletin 229, N. J. Agr. Exp. Sta.

† *Chætocnema confinis* Lec. Family *Chrysomelidæ*. See Smith, l. c., p. 4.

brassy-brown, about one-sixteenth inch long, thick set, and the wing-covers when seen under a lens are deeply striated.

Life History.—The beetles hibernate over winter in rubbish, under logs, leaves or other vegetation, and emerge early in May. They mate as soon as they have fed a little, and disappear by the middle of June in New Jersey. But little is known of the early stages of the insect and they have never been found on sweet-potato plants. The larvæ have been found, however, feeding on the roots of bindweed. The larva (Fig. 308) is a slender, white grub, about one-eighth inch long, and feeds externally upon

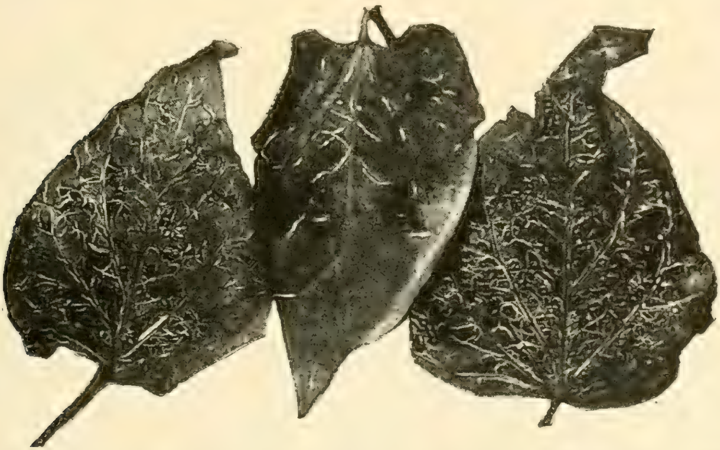


FIG. 309.—Sweet-potato leaves injured by the sweet-potato flea-beetle. (After J. B. Smith.)

the smaller roots. The beetles appear again in August, but do not as a rule feed on sweet potatoes, preferring bindweeds and wild morning-glories, from which they disappear in late September.

Control. By dipping the plants in arsenate of lead 1 pound to 10 gallons of water, as they are being set, they will be protected and any beetles feeding on them will be killed. The plants should be allowed to dry slightly before being set. Dipping the plants is much better than spraying them later, as it is practically impossible to completely cover the plant by spraying, as may be done in dipping, which is much quicker and less expensive. Late-

planted sweet potatoes are much less seriously injured, as the beetles will seek out their wild food-plants and become established upon them, so that late planting may be resorted to when necessary or more convenient. Well grown, stocky plants will better withstand injury, and liberal fertilization will enable them to make a quick growth even if slightly checked.

Tortoise-beetles or Gold-bugs *

Of all the insects affecting the sweet potato, the brilliant, little golden beetles which form one tribe (*Cassidæ*) of the large family of leaf-beetles, are the most common and are quite peculiar to it. They are beautiful insects, some of the species appearing like drops of molten gold, which has given them the name of "gold-bugs," while the broad expansion of the thorax and wing-covers gives them a fancied resemblance to a tortoise; hence the name "tortoise-beetles." The species affecting the sweet potato are classed in three different genera, but are sufficiently alike in their general habits and life history to be treated together.

Life History.—The beetles hibernate over winter and in the spring before the sweet-potato plants are set they feed on their native food-plant, the morning glory. As soon as the plants are set out, the beetles commence to eat large round holes in the leaves, and so riddle them that many must often be replanted. The worst damage, however, is done to the set on which the eggs are laid. Rarely are the new shoots seriously eaten or are eggs laid upon them. The larvæ hatch during the first half of June in Maryland, and require slightly over two weeks to become full grown. Though the larvæ do considerable damage by eating the foliage, it is not nearly as serious as that done by the beetles. The larvæ are almost as disagreeable as the adult beetles are attractive, but are nevertheless very interesting creatures. Each of them is provided with a tail-like fork at the end of the body which is almost as long as the body, and in those species in which it is depressed, entirely

* Family *Chrysomelidæ.*

conceals the insect. Upon this fork is heaped the exer. ment and cast skins of the larva, and w en covered by this "umbrella" it is with great difficulty that the larva is distinguished from a bit of mud or a bird-dropping. The manner in which this fork increases with the size of the larva is rather interesting. At each molt, the fæci-fork of the last stage is held upon the new fæci-fork, and in this way those of the different stages are telescoped, the one inside the other, and the stage of growth of the larva may be readily determined by the number of cast skins held on the fork. From the likeness of this burden to a pack, the larvæ are often known as "peddlers." In order to more firmly bind the excrement and cast skins to the fork, the larvæ fasten them together by a fine network of silken threads, which are attached to the spines at the sides of the body. When fully grown the larva fastens itself to a leaf, its skin splits open along the back, and from it comes the pupa, which is held to the leaf by its caudal fork, which is securely encased in the fæci-fork of the larval skin. About a week later the adult beetle emerges, eats for a few days and then disappears from the sweet-potato patch until the following spring, doubtless feeding on morning glory until it enters hibernation.

The Two-Striped Sweet-potato Beetle *

This is usually the most common of the tortoise beetles attacking sweet potatoes. The beetle is pale or brownish-yellow,

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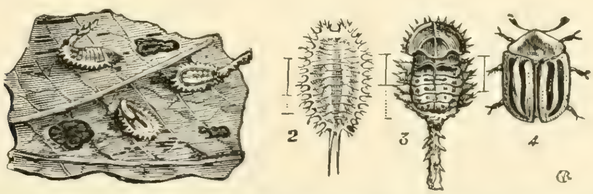

2 3 4

FIG. 310.—The two-striped sweet-potato beetle (*Cassida bivittata* Say): 1, larvæ on leaf; 2, larva; 3, pupa; 4, beetle—all enlarged. (After Riley.)

striped with black as shown in Fig. 310, and the larva is yellowish-white, with a longitudinal band along the back, on either side of

* *Cassida bivittata* Say. Family *Chrysomelidæ*.

which is a much lighter band. This species differs from the others in that the larva does not use its fæci-fork for carrying excrement, but merely covers it with cast skins and holds it at an angle from the body, instead of close over the back.

The Black-legged Tortoise-beetle *

This species very closely resembles the following one, the golden tortoise-beetle, but it is not so brilliant, is larger, has black legs, and the three black spots on each wing-cover are larger and more conspicuous. The larva is a bright straw-yellow, with two crescent-shaped black marks just back of the head and with the spines at the side of the body tipped with black. It is considerably larger than the larvæ of the other species and may be easily

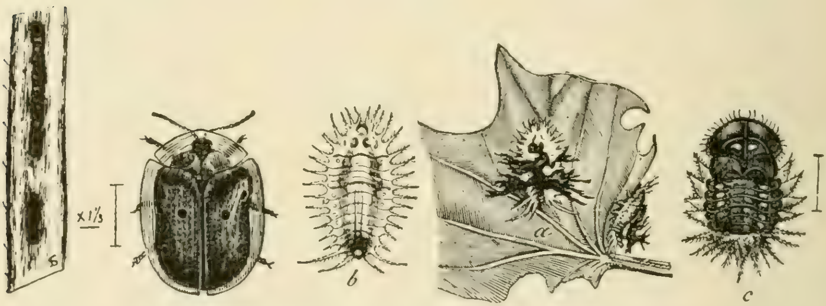


Fig. 311.—The black-legged tortoise-beetle. (*Cassida nigripes* Oliv.): *a*, *b*, larvæ; *c*, pupa; *d*, beetle. (After Riley.) Eggs at left—all enlarged.

recognized by the characteristic way in which the dung is spread on the fæci-fork (Fig. 311, *a*). The larvæ of this species also do more injury than the others, though possibly not as common. The eggs of the other species are laid singly, so that only one or two larvæ will be found on a plant, or if more occur they are scattered, but the eggs of this species are laid in rows of from three to a dozen, and upon hatching the larvæ feed together, thus making the injury more noticeable.

* *Cassida nigripes* Oliv. Family *Chrysomelidæ*.

The Golden Tortoise-beetle *

This is a very common species and may be found on morning-glory vines throughout the summer. The beetles upon first emerging are a dull orange color with three prominent black dots on each wing-cover, but a little later they change to a metallic gold, shining like the most brilliant tinsel, and the black spots are less noticeable. All of the tortoise-beetles, and this species in particular, have the habit of dropping quckly to the ground and feigning death when disturbed. The eggs are quite different from those of other species, having three spiny prongs projecting from the pos-

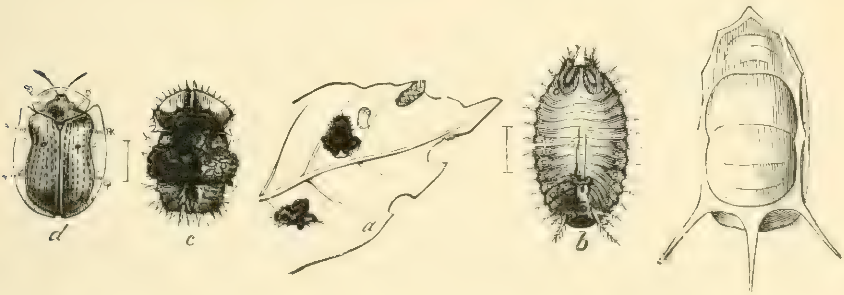


FIG. 312.—The golden tortoise-beetle (*Coptocycla bicolor* Fab.): *a, b,* larvæ; *c,* pupa; *d,* beetle; egg at right—all enlarged. (After Riley).

terior margin (Fig. 312). The larva is easily distinguished by being nearly concealed by the heavy load of excrement which is tri-lobed in outline. Though usually of a dark-brown color with a paler shade along the middle of the back, when the faeci-fork is raised the light color extends over the entire upper side. The pupa, with the loaded fork still held close to the back, is hardly distinguishable from the larva at first glance, but if the fork is removed it may be distinguished from nearly releated pupæ by the three dark stripes on the prothorax and similar markings over the abdomen.

* *Coptocycla bicolor* Fab. Family *Chrysomelidæ.*

The Mottled Tortoise-beetle *

This beetle is strikingly different from the other species in being black, marked with six irregular golden spots, and with a band of black extending across the shoulders to the edge of the transparent margin of the wing-covers. The larva is a pale straw-yellow color during the first four stages when it carries excrement on the fæci-fork in a peculiar branched shape much like that of the black-legged tortoise-beetle larva, but after the last moult the color changes to a pea green, and all the excrement is removed from the fæci-fork, which makes the larva very difficult to recognize on a green leaf. Inasmuch as the larva does not feed and remains entirely motionless during this last stage, this change of color is very evidently of protective value. The pupa is also a bright green, marked only by a black ring around each of the first pair of abdominal spiracles.

The Argus Tortoise-beetle †

This is the largest of the tortoise-beetles found on sweet potato, though not as common as the preceding, and is also injurious to raspberry and horseradish, and it feeds on milk-

Fig. 313.—The argus tortoise-beetle (*Chelymorpha argus* Licht.): *a*, beetle; *b*, eggs; *c*, larva—all enlarged.

weeds and species of *Convolvulus*. The beetles are usually a brick-red color, with six black dots on the prothorax and six on each wing-cover, but they are exceedingly variable in size and color,

* *Coptocycla signifera* Herbst. Family *Chrysomelidæ*.

† *Chelymorpha argus* Licht. Family *Chrysomelidæ*.

even from the same lot of eggs. The expansion of the margins of the wing-covers and prothorax found in the other tortoise-beetles is almost lacking. The eggs are laid in a bunch, each supported by a long stalk or pedicle. When the larvæ hatch they huddle together on the leaves and very rapidly defoliate a plant. When full grown a larva is about one-half inch long with the fæci-fork half as long again, slightly convex above, of a dirty yellowish color marked with numerous dark-brown tubercles and prominent lateral spines as shown in Fig. 313. The larva usually stands with the caudal segments elevated and the fæci-fork slanting backward. The pupa is of a yellowish color, marked with dark brown, which becomes almost black. The ground color of the pupa is almost concealed by a bluish bloom or waxy excretion resembling mold.

Control.—From the similarity of their life history and habits all of these species may be treated at once. As the beetles do the most injury just after the plants are set, they should be dipped in arsenate of lead when setting, as advised for the flea-beetle. If this has not been done or if the beetles are injurious in the forcing bed, the plants should be thoroughly sprayed with arsenate of lead, 3 pounds per barrel, or Paris green, $\frac{1}{3}$ pound per barrel with $\frac{1}{2}$ pound of freshly slaked lime.

Saw-flies *

In 1886, Dr. C. V. Riley described the injury and various stages of a saw-fly,† the larvæ of which had practically ruined a crop of sweet potatoes at Ocean Springs, Miss. The pest was somewhat injurious for the next two years, but since then has not been specially injurious, though adult flies have been noticed on sweet-potato and morning-glory vines in Nebraska. Doubtless its control is due to the effective work of parasites which were reared by Dr. Riley from the larvæ, and which probably prevent the undue increase of the species.

* Family *Tenthredinidæ*.
† *Schizocerus ebenus* Norton.

The larvæ of another insect of the same genus * was reported as seriously injuring the crop in Accomac County, Virginia, in 1891. Concerning this injury the grower, C. W. Stockley, wrote, "Last year (1890) was the first time they made their appearance in my potato patch. They came the first of July and deposited their eggs on the leaves; when the eggs hatched these worms would eat the leaves to a comb. This continued for about four weeks. The potatoes where the fly was did not make any yield at all. This year the fly made its appearance the same time as it did last year." Since then no injury has been reported by this species, though the adults are occasionally seen.

Control.—An arsenical spray as advised for the tortoise-beetles will be found effective for destroying the saw-fly larvæ and should be applied as soon as the injury is noticed, or preferably just as the eggs are hatching.

The Sweet-potato Root-borer †

Since 1890 sweet potatoes have been seriously injured in parts of Texas and Louisiana by a small white grub which bores into the stems and tubers both in the field and in storage, but strangely it has not spread elsewhere in this country. In Texas the worst injury has been in Calhoun and neighboring counties along the Gulf Coast where extensive growing of sweet potatoes has been abandoned on account of the pest. During recent years it has spread to central Texas and there seems to be no reason why it should not spread over the Gulf States. It is a cosmopolitan insect being reported from China, India, Madagascar, Australia and Cuba. It was first noticed in the vicinity of New Orleans in 1875 and has since spread northward along the Mississippi.‡ In 1879 it was reported from Florida and was studied by Professor J. H. Comstock.§

The adult beetle is a rather slender insect, about one-quarter

* *Schizocerus privatus* Norton.

† *Cylas formicarius* Oliv. Family *Curculionidæ.*

‡ Bulletin 28, La. Agr. Exp. Sta., p. 999.

§ See Report U. S. Comm. Agr., for 1879, p. 249.

inch long, of a bluish-black color, with a reddish-brown prothorax, and has received its specific name, *formicarius*, from its fancied resemblance to an ant.

Life History.—The yellowish-white, oval eggs are deposited in small cavities eaten out by the mother beetle either at the base of the vine or at the stem end of the tuberous root, or in the tubers in storage. The small grubs commence to burrow in the vine, sometimes maturing in the vine before any tubers have developed, but usually they descend to the tubers, which

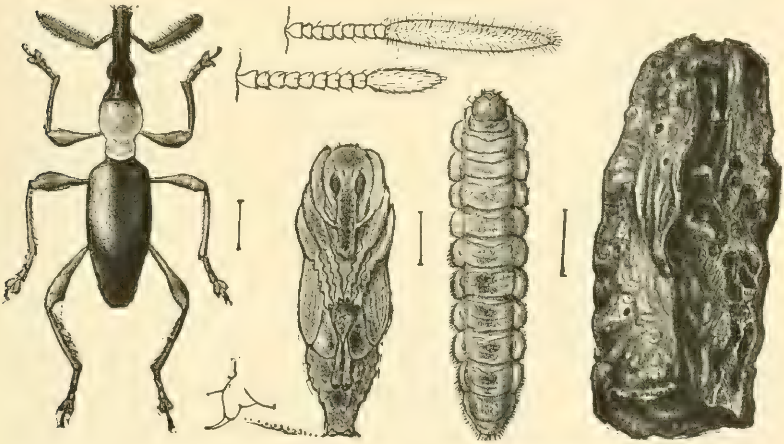


FIG. 314.—The sweet-potato root-borer (*Cylas formicarius*): extreme left hand figure, adult beetle, with enlarged antennæ at right; figure at left center, pupa; at right center, larva; at extreme right, portion of sweet-potato tuber channeled by borer—all figures except the last considerably enlarged; natural sizes indicated by hair lines. (After Farmer's Bulletin, No. 26, U. S. Dept. Agr.)

in the course of the season, and with the aid of the beetles, they thoroughly riddle. The full-grown larva is about one-quarter inch long, whitish with light brown head, the segments are strongly constricted, and the legs are wanting, being represented by mere tubercles. The grub forms a small cavity at the end of the burrow and transforms to the pupa. In this stage it remains from one to two weeks, when the adult beetle emerges and after a few days commences to lay eggs for another generation. The whole

life cycle requires from thirty to forty days, so that there may be several generations in a year, Professor Comstock having observed three generations. In central Texas the beetles hibernate over winter, but in south Texas they continue to breed in the bins during the winter.

Control.—The following measures of control are recommended by Professor A. F. Conradi, who has studied the species in Texas.*

"When the insect is known to be present, tubers should not be allowed to remain exposed, and should be covered with soil. Where beetle attack is anticipated, deep planting should be practiced, and if conditions will permit the planting should be in flats, because outbreaks will be more readily noticed than when planted in ridges. Such planting will permit of cultivation that will keep the cracks in the soil closed during drought, thus shutting up all entering channels by which the adults may reach the tubers. When the crop is known to be infested, it should be harvested as soon as possible, for every day the infestation will increase and the value of the crop will decrease. All tubers showing no sign of infestation should be separated from the infested ones. The former should be placed in a weevil-tight bin [and fumigated with carbon bisulfide if not sold immediately—E. D. S.], and the latter destroyed absolutely. The vines should be gathered and burned, and the grower should convince himself . . . that no vines or tubers remain in the field." The pest may be disseminated in sweet-potato sets intended for planting, and may be spread great distances by the tubers on the open market, so that seed potatoes or slips should be secured from localities known to be free from it or should be thoroughly fumigated. The weevils often gnaw the plants, and Professor Conradi advises thorough spraying with Paris green or arsenate of lead while they are feeding. Potatoes in bins should be thoroughly fumigated with carbon bisulfide, 5 pounds to 100 bushels for thirty hours (see page 57).

* See Bulletin 89, Texas Agr. Exp. Sta., p. 40.

CHAPTER XXII

INSECTS INJURIOUS TO THE STRAWBERRY *

The Strawberry Root-louse †

If bare spots are found in the strawberry bed and the neighboring plants are unhealthy, the presence of the root-louse may be suspected, especially if ants are abundant around the plants. If present, the small dark green or blackish aphides will be found clustered on the roots and stems, causing the plants to wither and die. The individual aphid is only about one-twentieth inch long, and deep bluish or greenish-black when mature, the younger stages being lighter, and somewhat pear-shaped as shown in Fig. 315.

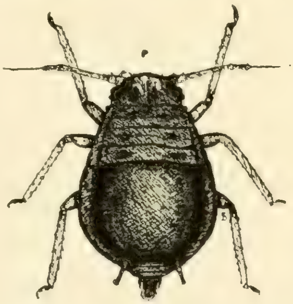


Fig. 315. — The strawberry root-louse (*Aphis forbesi* Weed): wingless viviparous female of late summer—greatly enlarged.

Injury by this pest was first noted in southern Illinois in 1884 and a few years later it became troublesome in Ohio. In the late '90s it ruined many beds on the Maryland-Delaware peninsula and became established in New Jersey. Since then it has become distributed on plants throughout most of the States east of the Rockies, injury having been noted in New Hampshire, Michigan, Minnesota, Kansas, Texas, and Kentucky. Injury is most severe on light sandy

* See L. Bruner, Report Nebraska Horticultural Society, pp. 49–100; J. B. Smith, Bulletin 225, N. J. Agr. Exp. Sta.; A. L. Quaintance, Bulletin 42, Fla. Agr. Exp. Sta.; S. A. Forbes, 13th Report State Ent. of Ill., pp. 60–180.

† *Aphis forbesi* Weed. Family *Aphididæ*. See Sanderson, Bulletin 49, 12th, 13th and 14th Reports, Del. Agr. Exp. Sta.

soils and the pest rarely becomes very troublesome on heavier soils. Injury is also more or less periodic, the aphides almost disappearing after doing serious injury for two or three years. Fortunately the strawberry is the only food plant and the root-lice found on other crops are entirely different species.

Life History.—During the winter the small, shining black eggs may be found thickly clustered upon the stems and along

Fig. 316.—Strawberry root-lice clustered on small rootlets from crown of plant—greatly enlarged.

the midribs of the green leaves. They are mere specks, one-thirty-fifth inch long and oval in shape. In early winter as many as sixty-five have been found on one leaf, but many fall off and are destroyed before spring. The eggs hatch early in April in Delaware, the exact time depending on the season. The young aphides feed a little on the leaves bearing the eggs but soon find their way to the tender young leaves of the crown. These

aphides of the first generation become full grown in twelve to fifteen days. The adults soon commence to give birth to young aphides, bearing fifteen or twenty within a few days. All of the aphides of this generation are females, as are all those of the summer generations, the males appearing only in the fall. The young of the second generation mature and reproduce in the same manner and in about the same time as the first generation. Until the last of April but few ants are seen, but about that time they

FIG. 317.—Eggs of strawberry root-louse on leaf stem.

become active and carry the young aphides from the leaves down to the roots, where a colony of a dozen or more is established on each plant. No aphides are found on the roots until the ants appear, and they are entirely responsible for the aphides infesting the roots. The ants continue to care for the aphides during the summer, carrying them to new plants when they become overcrowded or the plant dies, and so are responsible for the spread of the pest. The first generations are entirely wingless, but when the third generation matures a large number are winged. These

winged females are common in late May and early June. Their bodies are somewhat smaller than those of the wingless forms, and appear to be shiny black, though really a deep green. The wings expand about one-sixth inch, slightly over three times the length of the body. They are also carried to the roots by the ants, wherever they are found, and most of them deposit their young on the roots. Although these winged females aid in spreading the pest in a bed, they probably do not migrate far unless

FIG. 318. Strawberry root-lice which have been killed by parasites, with one of the little parasitic flies which has just emerged.

carried by the wind from a badly infested bed where they have become overcrowded. Reproduction continues, one generation following another about every two weeks, during the summer and early fall. Part of the fourth generation is winged, but the remaining generations are wingless. In Delaware the viviparous females are common on the roots until cold weather, but doubtless further south they may continue to reproduce during the winter. Late in October and early in November the offspring develop into

true males and females which pair and reproduce by eggs. The egg-laying females are very similar to the summer generations in general appearance, though of a green color, with often a yellowish or reddish shade on the middle of the abdomen. The males are much smaller and are hardly to be distinguished from the third stage of the female nymphs, and are greatly outnumbered by the females. Each female deposits about four eggs, which are at first a bright orange color, but turn black in a day or two.

Were it not for its parasitic enemies this insect would always be a most formidable strawberry pest, but fortunately they are very efficient in its control whenever it becomes abundant. The adult parasites are little wasp-like flies,* nearly related to those which parasitize the melon-aphis and green-bug. They deposit their eggs in the plant-lice, and the maggots live within the aphides, usually but one in each. The aphid soon dies from the effects of the parasitism, the skin becoming dry and inflated, from which shell the adult parasite emerges through a circular hole as shown in Fig. 318. Such parasitized aphides are easily recognized and should never be destroyed.

Control.—To prevent injury care must be taken to secure uninfested plants and to plant them on land not already infested. Do not replant berries on infested land until it has been in some other crop for a year or two. As the aphides and their eggs are readily transported on plants, it is important that they be secured from sources known to be free from the pest. If there is any doubt about this or if they are known to be infested, the plants should be disinfected before setting. This can be done only after all the eggs have hatched, as there is no treatment that will kill the eggs without injuring the plants. Setting must be delayed, therefore, until all eggs have hatched. The most practicable method for disinfecting plants is to dip them for a few minutes in tobacco decoction or dilute tobacco extract. Other dips will kill the aphides, but sometimes injure the plants, while tobacco water has been found efficient and safe. Plants may be fumigated

* *Lysiphlebus testaceipes* Cress., and *Lygocerus stigmatus* Say.

with hyrdocyanic acid gas by the nurseryman or large grower (see the author's Delaware bulletin). If a new bed be planted near an old one it may become infested when the winged aphides appear in early summer and to prevent their migration it may be advisable to plow up the old bed some time before the winged aphides appear, or preferably the previous fall. One of the best

Fig. 319. —A Delaware strawberry bed in summer of 1900 showing injury by the strawberry root-louse.

means of reducing the number of aphides in a bed is to burn it over with a quick hot fire in early spring. Straw or grass should be scattered over the bed and burned just as the growth of the plants is commencing. As all the eggs and young aphides are on the leaves and stems, this will practically clear the bed of the pest, as well as many other insects and diseases, and if properly done will result in no injury. This has been found satisfactory in Delaware, but if farther south, the aphides winter on the roots, it would not be as effective.

The Strawberry Crown-borer *

Strawberry plants are often dwarfed or killed by a small white larva which mines out the interior of the crown, hollowing it out from the bases of the leaves to the larger roots. Usually but one grub is found in a plant, and it looks very much like a small white grub as it lies curled in its burrow. It is only about one-quarter inch long, and legless, the body being white and the head yellowish brown. The adult beetle is a small snout beetle about one-fifth inch long, of a dark color, with head and thorax nearly black, and on each wing-cover are three black spots, the middle one being the largest and separated from the others by pale lines. According to Professor Garman the wings are too small to be used

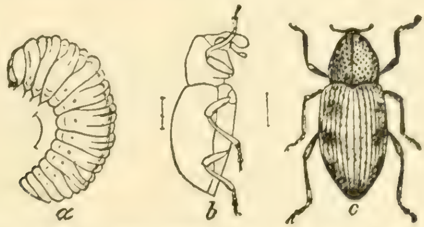


Fig. 320.—The strawberry crown-borer (*Tyloderma fragrariæ* Riley): *a*, larva; *b*, *c*, beetle—enlarged. (After Riley.)

for flight and this doubtless accounts for the slow spread of the pest. Injury has been reported from Illinois, Kentucky, Missouri, and Nebraska, but as the larvæ might be readily shipped in plants, it is quite probable that it has become generally distributed but has not done sufficient injury to attract attention.

Life History.—The beetles appear during the latter part of summer and fall and hibernate over winter in the soil, emerging early the next spring.. The eggs have not been observed, but are undoubtedly laid on the crown between the bases of the leaves in late spring. The larvæ develop in the crowns and become full grown by midsummer or August when they pupate in the cavities

* *Tyloderma fragrariæ* Riley. Family *Curculionidæ*. See S. A. Forbes, 12th Report Ill. State Ent., p. 64; 13th Report, p. 142; H. Garman, Bulletin 80, Ky. Agr. Exp. Sta., p. 261.

formed and the adult beetles emerge in late summer and fall. There seems to be but one generation a year. Old plants are worst injured, and runners formed late in the season are usually free from the pest, as eggs are probably not laid after June.

Control.—Frequent rotation, plowing up the bed after one or two crops, will largely prevent the pest becoming established. Where the insect is well established in old beds, it will be well to secure plants from beds known to be free from the pest and to plant new beds at some distance from the old ones. Infested beds should have the plants plowed out and raked up and burned as soon as possible after the fruit is harvested and before August. Owing to the fortunate fact that the beetle cannot fly from field to field, if the above measures are consistently carried out there should be no trouble in controlling the injury.

Strawberry Rootworms *

The larvæ of three species of common leaf-beetles often feed upon the roots of the strawberry and are easily mistaken for the crown-borer or for small white grubs. They may be distinguished from the former by having three pairs of small thoracic legs just back of the head, and from the latter by their being much thicker. These rootworms are from one-eighth to one-sixth inch long, whitish, with brownish heads, and usually feed on the roots externally, though sometimes boring into them or the crown. Dr. Forbes * has indicated the structural differences by which they may be separated and shows that their life histories are quite dissimilar. "The larva of *Colaspis* appears early in the season, and does its mischief chiefly in the months of April and May, the beetles beginning to emerge in June. That the eggs are laid in the preceding year is highly probable, in which case the species hibernates in the egg. *Typophorus*, on the other hand, certainly passes the winter as an adult, doubtless laying its eggs in spring, and making its principal attacks upon the plants in June and

* *Typophorus canellus* Fab., *Colaspis brunnea* Fab., *Graphops pubescens* Mels. Family *Chrysomelidæ*. See Forbes, l. c., p. 150.

July, the beetles emerging in the latter part of July and early in August. *Graphops* hibernates in the larval condition, pupates in the spring, and emerges in May and June. The eggs are probably laid in July, and the larvæ make their attack upon the plant in August and September. . ."—Forbes. Thus the larvæ of the three species may be found throughout the season where all occur. The beetles are about one-eighth inch long and may be distinguished as follows, according to Bruner: "*Colaspis brunnea* is usually of a yellowish clay color, but ranges to yellowish-brown. The body is smooth but not shining. *Typophorus canellus* is usually shiny, black above, varying to brown, with four black blotches on the wing-covers. The legs and antennæ are always pale. *Graphops pubescens* is either green or purple with a bronze metallic sheen, and has

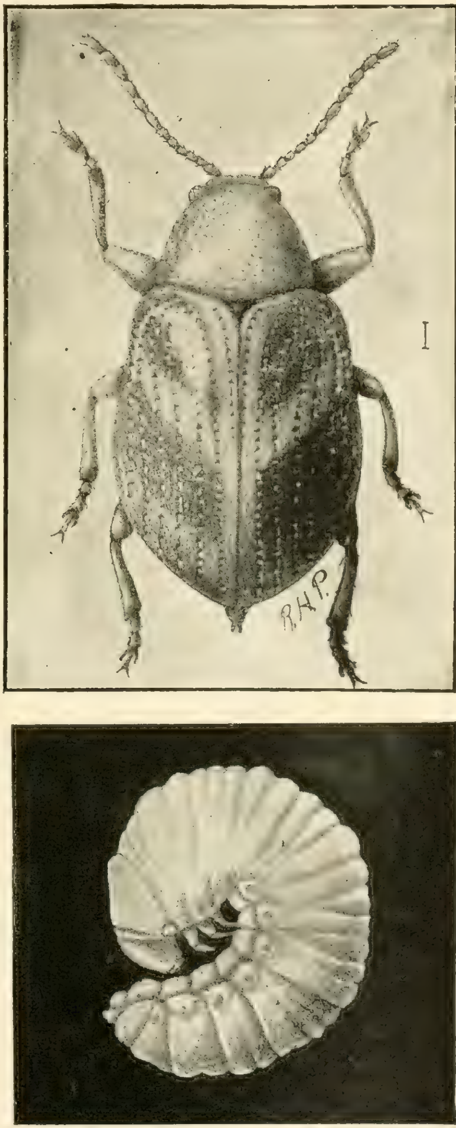


Fig. 321.—The strawberry root-borer (*Typophorus canellus* Fab.): adult and larva—very great'y enlarged, hair line at right of beetle shows natural size. (After Pettit.)

the entire body more or less covered with a gray pubescence." The pupæ are all found in earthen cells among the roots of the plants. The beetles of all three species feed on the foliage and when numerous will attract attention.

Control.—Whenever the plants are not in fruit, the beetles may be destroyed by spraying with $\frac{1}{3}$ pound of Paris green or 3 pounds or arsenate of lead per barrel, preferably applied with Bordeaux mixture. Where the plants are customarily sprayed with Bordeaux mixture for leaf diseases, arsenites may be added and will probably control this and other strawberry pests. Badly infested fields should be plowed under deeply as soon as the crop is secured and new beds should be planted at some distance from them.

The Strawberry Saw-fly *

Occasionally the strawberry leaves are skeletonized by yellowish or greenish "worms" one-half to three-quarters of an inch long when full grown. The head is yellow with two brown spots

FIG. 322.—The strawberry saw-fly (*Harpiphorus maculatus* Norton): 1, 2, pupa; 3, 5, adult flies; 4, 6, larvæ; 7, cocoon; 9, egg—all enlarged. (After Riley.)

on the side and one or two on top, and there are eight pairs of yellowish abdominal prolegs, in addition to the true thoracic

* *Harpiphorus maculatus* Norton. Family *Tenthredinidæ*. See J. M. Stedman, Bulletin 54, Mo. Agr. Exp. Sta.

legs, which at once distinguish the saw-fly larvæ from true caterpillars. The adult saw-flies are about one-quarter inch long, with two pairs of blackish, well-veined wings which are folded over the abdomen when at rest. The body is black, with a row of lighter spots on either side of the abdomen. The flies emerge in late April in Missouri or about a fortnight before the plants flower freely. The eggs are inserted just beneath the epidermis of the leaves and hatch in about two weeks, just as the plants begin to bloom. The larvæ eat holes in the leaves and "where numerous, they will defoliate the plants to such an extent as to greatly injure or completely destroy the crop of fruit, and may even kill the plants themselves." When at rest or disturbed the larvæ coil themselves up in a spiral on the under side of the leaf as shown in Fig. 322, but if suddenly disturbed they will often drop to the ground. By the last of May the larvæ are full grown and enter the soil, where they make small cells, lined with a gummy substance, and in them hibernate until the next spring, when they pupate and the adult flies emerge.

Injury by the saw-fly has been reported from the northern and central States from Missouri and Nebraska to Maine.

A nearly related species * with almost identical habits has done similar injury in Iowa, Illinois and Indiana. The larvæ are a deep green, much wrinkled, with a blackish stripe along the back and an obscure blackish stripe on each side, and the head brown.

Control. Inasmuch as the larvæ commence to hatch just as blooming commences Professor Stedman has shown by experiments that spraying the foliage at this time with arsenicals will entirely protect it from the larvæ. If they commence work before their presence is noticed, the foliage may be sprayed until the first berries are about one-third grown without any danger of poisoning them. Hellebore 1 pound to 3 gallons of water was also effective, as was dusting with pyrethrum. Although there may be some prejudice against the use of arsenicals, where properly applied at the right time there is no reason why they should not be used.

* *Monostegia ignota* Norton. See F. W. Mally, "Insect Life," Vol. II, p. 137.

The Strawberry Leaf-roller *

Where leaves are found folded together, many of them being dry and brown, the small green caterpillars found feeding within the folds are probably those of the Strawberry Leaf-roller. It is a European insect, though it is not injurious there, and the first record of injury in this country was made by Dr. C. V. Riley in 1869, who stated that in one place in Missouri it destroyed ten acres so completely as to not leave enough plants to set a half acre. "Since that time," says Dr. J. B. Smith, "the insect has been frequently mentioned as injurious in many parts of the country, but rarely is it troublesome for more than a year or two

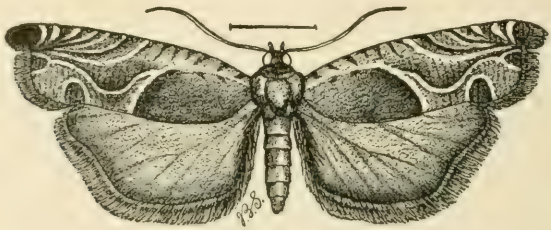


Fig. 323.—The strawberry leaf-roller moth (*Ancylis comptana* Fröhl.)—enlarged. (After J. B. Smith.)

in succession. It is always inclined to be local and its ravages do not often extend over wide areas."

Life History. The moths appear in the strawberry fields during early May in New Jersey and commence to lay eggs, the moths being found in the fields for about a month. The eggs are laid on the under surface of the half-grown leaves. They are broadly oval or round, much flattened, of a pale green color and about one-fiftieth inch in diameter. They are laid in the fine netting of the leaf, in which they are seen with great difficulty. The larvæ hatch in from five to seven days. The young caterpillar feeds on the upper surface of the leaf for a day or two, eating into and along the midrib to weaken it. The young larva is at

* *Ancylis comptana* Fröhl. Family *Tortricidæ*. See J. B. Smith, Bulletins 149 and 225, N. J. Agr. Exp. Sta.

first a light-green color with a large head and long hair, which becomes less noticeable as it grows.

It soon commences to draw the edges of the leaf together, folding the upper surface on the midrib, holding it together by numerous strands of fine silk. The insect then spins a partia tube or lining inside, in which it remains until the moth develops. Unless disturbed the larva does not leave this folded leaf, and all

Fig. 324.—Strawberry leaf folded by the leaf-roller. (After J. B. Smith.)

the feeding is done out of the reach of sprays. The larva becomes full grown in about four weeks, when it is about half an inch long and of a dark-green color, until just before pupation, when it becomes more yellowish. The head and thoracic shield are shining brown, and the small body tubercles are slightly lighter. The larvæ are slender and very active, wriggling violently when disturbed or taken from their webs.

"Pupation occurs in the tube made by the larva. The pupa itself is brownish-yellow, without obvious processes or protuberances, and a little more than one-fourth an inch long." The pupal stage lasts about ten days, thus giving about forty-two to fifty days for the complete life cycle from egg to adult.

The moths of the second brood appear late in June and during July. This brood is much more abundant on blackberry and raspberry than on strawberry plants. The moths of the third brood appear in August. They are comparatively few in number and also seem to prefer blackberry and raspberry. Young larvæ are, however, to be found on strawberries in September. "According to the account given by Riley, the larvæ change to pupæ late in September and remain during the winter in that state." Dr. Smith states that he has not observed this personally. In Delaware we have found full-grown larvæ in folded leaves in midwinter, so that possibly some of them at least do not pupate until spring.

"The adult moth is small, measuring with expanded wings about two-fifths of an inch. In general color it is somewhat reddish-brown, the fore-wings streaked and spotted with black and white as shown in the illustration. When the wings are folded, the dark area at the base forms a somewhat conspicuous deeper brown patch in the middle of the back. The hind-wings are of a soft, dark smoky gray, and both wings have long fringes. The insects fly readily during the middle of the day, and run rapidly on the leaves, diving to the under side or into a fold so quickly that it requires close watching to follow their movements. From the fact that newly set fields are often infested, it is probable that they fly for some distance to seek their food plant."—Smith.

"A badly infested strawberry-patch begins to look scorched early in June, and before the middle of that month appears as if a fire had been over it. The fruit, deprived of the food prepared by the foliage, stops growth, ripens undersized or prematurely, or shrivels up altogether, even before it colors." "Often every lobe on a leaf will be folded, and occasionally, when infested

leaves cover or touch, an irregular mass of foliage is bundled up in which as many as six or eight larvæ may be found.

"On blackberry not so large a part of the leaf is involved, and frequently only the tip of one of the leaflets is webbed up. Furthermore, the injury is more local, and only that part that is actually eaten is harmed. The total amount of food really devoured is very small, and were it not for the manner of feeding, which interferes with the nutrition of the leaf, the strawberry could easily spare tissue for all these caterpillars that ever infect it. On the raspberry the habit is yet different. Here the larva gets into a partly opened tip and webs it together so securely as to check growth. The actual eating shows a rusty space on the upper side of the leaf, and not much more harm is done."

Control.—As stated above, the young caterpillar, just after it is hatched, goes to the upper surface of the leaf and feeds there exposed for a day or two before folding the leaf. "It must be the object of the grower to poison the foliage so early in the season that when the young caterpillar starts feeding, it can find no foliage it can safely eat. Therefore, as soon as moths are found flying in fair numbers, spray with Paris green, or some other arsenite (preferably arsenate of lead). As the plants grow rapidly, spray again a week later, and a third time a week thereafter. This will catch the great bulk of the caterpillars that will become injurious in June, leaving only a very few that hatch late and cannot cause much harm. A single spraying will do comparatively little good, because the moths extend the egg-laying period over so long a time. The first larvæ are almost full grown before the last eggs are hatched."

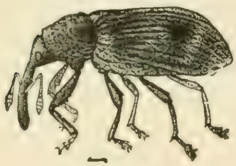
"If for any reason no timely applications were made and the fields become badly infested, nothing practical can be done until the crop is off. Then mow the beds, rake off all the foliage, and burn it. You will burn with it all the larvæ and pupæ that are then unchanged. This lessens the number of moths that come to maturity and so helps somewhat for the following year."

"On blackberry and raspberry no remedial measures have proved necessary so far. If there are many caterpillars present

late in the summer it may pay to handpick all infested leaves or to crush the larva in the folded leaf. This will tend to lessen the number that live over winter."

The Strawberry Weevil *

If the buds appear to be "stung" so that they wither, and if many of the stems are cut so that the buds drop to the ground, the strawberry weevil is the probable cause of the damage. This little weevil is only about one-tenth inch long and so is often unnoticed, and the loss is attributed to other causes. The weevil varies from nearly black to dull red, with a dark spot just back of the centre of each wing-cover. The head is prolonged into a slender curved snout, about half as long as the body. The species is found in most of the States east of the Rockies, but injury has been most severe in the Middle and Northern States.



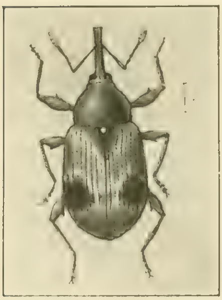


Fig. 325.— The strawberry weevil (*Anthonomus signatus* Say)— enlarged. (After Riley and Chittenden, U. S. Dept. Agr.)

Life History.— The weevils hibernate over winter and appear in spring a few days before the earliest staminate varieties commence to bloom. Others emerge during the next month, but the most injury is done within the next two weeks. The injury is done by the females, which eat small holes through the outer husk or corolla of nearly matured buds, and in these little cavities deposit their eggs. The stem of the bud is then cut so that it hangs by a mere thread and soon falls to the ground. By severing the stem the development of the bud is arrested, thus preventing the outer covering from unfolding and holding the eggs and larvæ in the pollen, on which they feed, and by falling to the ground

* *Anthonomus signatus* Say. Family *Curculionidæ*. See F. H. Chittenden, Circular 21, Div. Ent., U. S. Dept. Agr.; J. B. Smith, Bulletin 225, N. J. Agr. Exp. Sta.

the bud remains moist and will not dry up as it would on the stem. The eggs hatch in from six to seven days and the small whitish larvæ feed on the pollen and later on the harder parts of the buds. Three or four weeks are required for a larva to become full grown. It then forms a little cell in the bud, in which the pupal stage is passed in from five to eight days, when the adult beetle emerges and cuts its way out. Thus the complete life cycle occupies about a month and in the District of Columbia the new generation of beetles appears during June. They are frequently found in

FIG. 326.—The strawberry weevil: *a*, *b*, spray showing work in bud and stem—natural size; *c*, outline of egg; *d*, larva; *e*, head of same; *f*, pupa; *g*, bud opened to show egg on left and punctures made by snout of beetle through petals. (After Chittenden, U. S. Dept. Agr.)

large numbers on strawberry flowers and on those of the horse mint (*Monarda fistulosa*), but the beetles soon seek hibernating quarters, there being but one generation a year.

Control.—As the larvæ feed upon the pollen of the buds of staminate varieties, the staminate varieties are most injured, and injury may be avoided by growing as few rows of staminate varieties as are necessary for fertilizing the rest of the bed. Indeed the very early staminate varieties might be used as a trap crop for attracting the weevils, which might be destroyed by covering the rows with straw and burning, or possibly by spraying with

arsenicals. By planting rows of early varieties, which flower freely and produce an abundance of pollen near woods and fence-rows where the beetles have hibernated and appear first, they might be effectively trapped, and then destroyed. Although the larvae cannot be reached with any insecticide, the beetles feed more or less on the buds and foliage, and further experiments should be made in spraying for them with arsenicals. In view of the recent success in the use of arsenate of lead against the plum curculio, we would suggest the thorough spraying of badly infested beds with arsenate of lead 3 to 5 pounds per barrel, applying it with an under-spray nozzle so as to thoroughly cover every bit of foliage. This should be applied as soon as the buds commence to form and probably a week later before they blossom, as it is then that the beetles are feeding. Spraying at that season can do no possible harm to the berries, and to spray after the buds are injured is useless. The destruction of all trash and rubbish in and around the fields during the winter will destroy some of the hibernating weevils, and it will be well to avoid mulching the beds where the beetle is troublesome, if the mulch is not absolutely necessary, as it furnishes them the best hibernating quarters.

CHAPTER XXIII

INSECTS INJURIOUS TO RASPBERRY AND BLACKBERRY *

The Raspberry Root-borer †

The larvæ of the Raspberry Root-borer make tunnels in the roots and lower stems of raspberry and blackberry, sometimes completely girdling the stem at the crown, so that the name of blackberry crown-borer has also been used. The full-grown larva is from 1 to $1\frac{1}{2}$ inches long, yellowish-white, with brownish head, and the tips of the small thoracic legs also brownish. The parent insect is one of the clear-winged moths, which fly by day and closely resemble wasps, and is nearly related to the peach- and squash-borers. The female is much the larger and is shown natural size in Fig. 328. The body is black with yellow rings, and the legs are yellowish. The wings are transparent except a bronze-brown margin and a narrow band across the fore-wings about one-third from the tip.

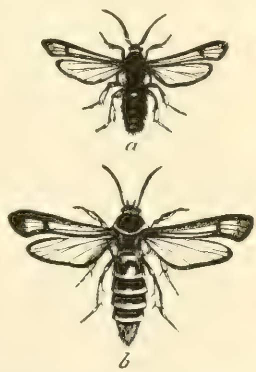


Fig. 327.—The raspberry root-borer (*Bembecia marginata* Harr.): *a*, male moth; *b*, female moth — natural size. (After Riley.)

Life History.—The moths appear in late August and September and the females deposit their eggs upon the lower edge of the leaves. The egg is oval, about one-

* See F. M. Webster, Bulletin 45, Ohio Agr. Exp. Sta.; J. B. Smith, 12th Report N. J. Agr. Exp. Sta.

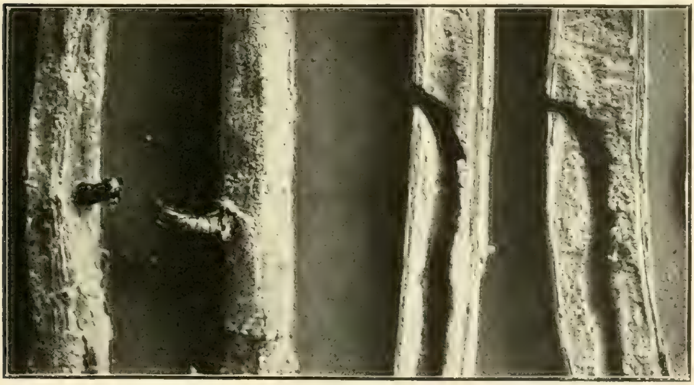
† *Bembecia marginata* Harr. Family *Sesiidæ*. See J. B. Smith, Bulletin N, N. J. Agr. Exp. Sta., p. 9; W. H. Lawrence, Bulletin 63, Wash. Agr. Exp. Sta.

sixteenth inch long, deep brownish-red in color. A female lays about 140 eggs, which are deposited singly. They hatch in September and the young larvæ crawl down the stems and bore under the bark. Here they may either make a small blister-like cavity and hibernate over winter, or if hatched earlier they may feed on the sap wood or occasionally bore into the stem and become one-quarter inch or more long before winter. The next season the larvæ bore in the lower stem and roots, but the nature of the injury differs as observed in different places. In New Jersey, Dr. J. B. Smith states that the larvæ girdle the stem at the crown, causing the plants to die. In spring they abandon the old wood and attack new shoots, but he observed none entering the stems. In Washington, the infested plants seldom show any signs of the presence of the borers other than a poor growth, though occasionally a few hills will die where the roots have been badly riddled by the larvæ, the injury being mostly in the

FIG. 328.—Raspberry root-borer (*Bembecia marginata* Harr.): *a*, female and male larvæ full grown; *b*, male and female pupæ; *c*, female, and *d*, male moths resting on leaf; *e*, *e*, eggs—slightly reduced. (After Lawrence.)

roots. "The borer," according to Lawrence, "first enters the roots and tunnels through them promiscuously until the second spring, and then directs its course upward, entering and eating the pith of the cane for a distance of one to five inches." At the end of the first summer the larva is one-half to three-quarters inch long. By the middle of the second summer the larva is full grown and bores an exit hole through the wood and bark just above the crown, leaving the hole covered by the epidermis only. The larva then descends into the tunnel and pupates.

The pupa is about three-quarters inch long, reddish-brown, the



a *b*

FIG. 329.—Work of the raspberry root-borer: *a*, two canes with empty pupa cases projecting from burrows; *b*, canes showing opening of tunnel through which pupæ have wriggled out. (After Lawrence.)

head bears a sharp-pointed process, and each abdominal segment bears two transverse rows of sharp teeth. By means of these the pupa wriggles itself out of the burrow until it projects from the aperture, and the adult moth emerges. This insect occurs throughout the Middle and Northern States east of the Rockies, is injurious in Washington and around Vancouver, B.C., and has been observed in Colorado and New Mexico.

Control.—The only method of control is to pull up the infested canes, root and branch, and destroy them by burning. As this is the only means of controlling several pests of cane fruits, the

canes should always be gone over in spring and those showing any injury examined and removed if affected.

The Raspberry Cane-borer *

If the tips of the young shoots of raspberry and blackberry are found withered and dying they have probably been girdled by the cane-borer. The adult beetle is about one-half inch long, with a slender, cylindrical body and long antennæ, and of a deep black color except the prothorax, which is yellow with two or three black spots, though these are sometimes lacking.

Life History.—The beetles appear in early summer and the females girdle the young tips by cutting two rings around the

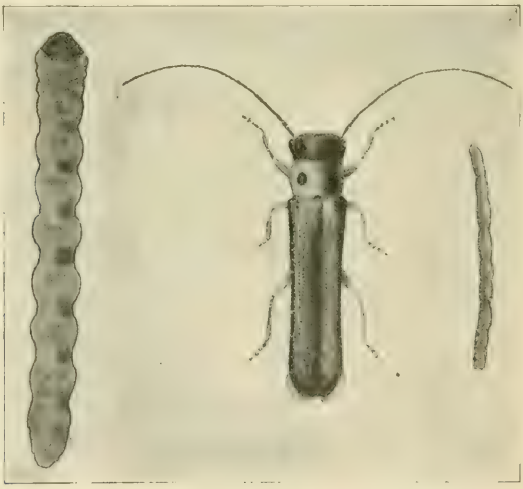


Fig. 330.—The raspberry cane-borer (*Oberea bimaculata* Oliv.): adult, larva, and larval castings—all enlarged. (After Lugger.)

shoot about an inch apart, causing the tip to wither and droop. Between these rings will be found a small dark spot where the female has inserted an egg in the cane. A rather large, elliptical, yellow egg is placed in the pith of the cane and in a few days hatches into a small white grub. The larvæ burrow downward

* *Oberea bimaculata* Oliv. Family *Cerambycidæ.* See Comstock and Slingerland, Bulletin 23, Cornell Univ. Agr. Exp. Sta., p. 122.

through the pith of the stems, the burrows winding from side to side and frequently penetrating the side of the stem, where openings are made every few inches, through which long strings of excrement are cast out. By fall they have bored to the base of the cane, in which they hibernate over winter. The full-grown larva is about one inch long, of a dull yellow color, with a small dark-brown head. The body is quite cylindrical and

FIG. 331.—Egg of the raspberry cane-borer, showing girdling of cane. (Photo by Headlee.)

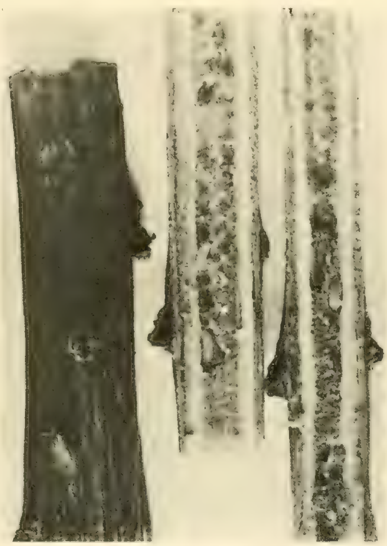


FIG. 332.—Young grubs and exit hole of the raspberry cane-borer. (Photo by Headlee.)

the segments constricted as shown in Fig. 330. The pupal stage is passed in the burrow during the spring. Although it has been generally assumed that the life cycle is passed in a single year, there is some reason for believing that two years may be required. The eggs are usually laid only in the young tips, but Comstock and Slingerland found larvæ somewhat over half grown which had made burrows only two inches long in old canes in late July, and Professor Webster has secured larvæ over half grown in early June. Possibly,

therefore, two years may be required for maturing a generation, and the fact that the pest does not increase may be due to the cutting back of the injured tips of the young canes.

Control.—As soon as the tips are seen to droop they should be cut off below the point girdled and burned. When the entire canes die from the effect of being tunneled, they should be cut in late summer before the larvæ have gone to the base to hibernate. Where such measures are practised the pest may be effectively controlled.

The Snowy Tree-cricket *

When the canes fail to put out leaves in the spring and are found to be dead, this often proves to be due to a long ragged wound like that shown in Fig. 334*a*. "If the rough surface of the wound be cut away with a knife, the injury will be found to consist of a longitudinal series of punctures placed close together. By splitting the cane the nature of the injury can be seen even better. Such a section is shown at *b* in the figure. The punctures extend through the woody part of the cane into the pith, and here there is in each an oblong, cylindrical egg. One of these eggs is represented enlarged at *c*. The insect which thus seriously injures the raspberry canes in preparing a safe receptacle for its eggs is a delicate greenish-white cricket. On account of its color and its habit of living among the foliage of trees and shrubs, it has received the popular name of the Snowy Tree-cricket. Fig. 333*b* represents the male. Its wing-covers are crossed by oblique thickenings or ribs, which form part of the musi-

a *b*

Fig. 333.—The snowy tree-cricket (*Oecanthus niveus* De G.): *a*, female; *b*, male—enlarged. (After Summers.)

* *Œcanthus niveus* DeG. Family *Gryllidæ*. See Comstock and Slingerland, Bulletin 23, Cornell Univ. Agr. Exp. Sta., p. 124; H. O. Houghton, Entomological News, Vol. XIV, p. 57.

cal apparatus of the insect. The female, Fig. 333*a*, differs somewhat in appearance from the fact that the wing-covers are wrapped closely about the body, making the insect much narrower than her mate." (Comstock and Slingerland, l.c.) The cry of these tree-crickets is well known, sounding much like that of the katy-did, but is less rasping and more monotonous. They are heard in early evening until well into the night, and in the North their chirp is the most noticeable of all the insect noises at that time. This species is quite widely distributed and frequently oviposits in the tender twigs of fruit trees, which are similarly injured, and in the stalks of cotton and various woody weeds.

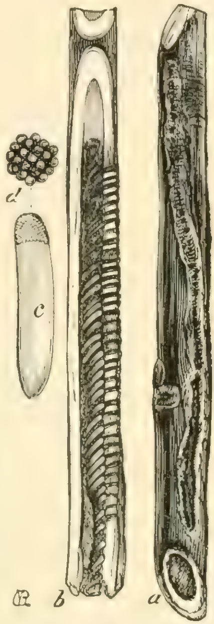


FIG. 334.—Raspberry stem injured by the snowy tree-cricket: *a*, wound made by egg-punctures; *b*, longitudinal section through same showing eggs in pith; *c*, egg enlarged; *d*, cap of egg, more enlarged. (After Riley.)

Life History.—The eggs are laid in the fall and hatch in the late spring. The nymphs feed mostly on plant-lice and other insects, as do the adults, and though they occasionally nibble foliage, they are never injurious, and both nymphs and adults must be regarded as beneficial as far as their feeding habits are concerned. In the North the nymphs become full grown late in July, and there is but one generation a year, but in Texas they become full grown late in June and eggs laid in early July hatch in about two weeks; nymphs are common in late summer, and the adults of the second generation in fall.

Control. — By examining the canes as soon as the foliage starts, those injured may be detected and should be cut out and burned. If not numerous enough to do appreciable damage they may be ignored.

The Red-necked Cane-borer *

Sometimes the canes of raspberry and blackberry are found with one or more elongate galls, not over one-third larger in diameter than the normal cane, and usually with numerous slits, which have been called the "gouty gall." The infested shoots

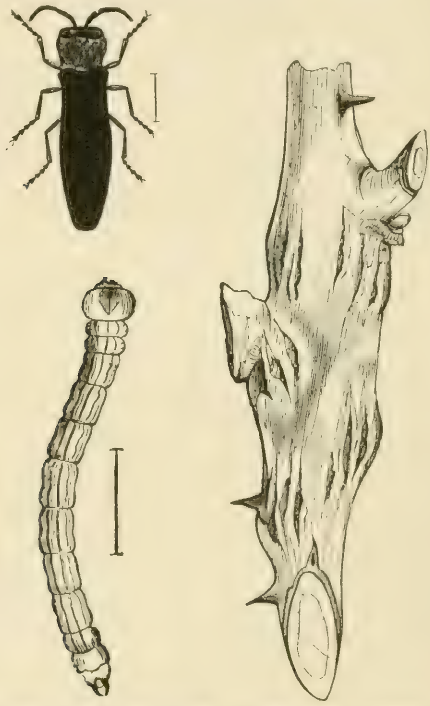


FIG. 335.—The red-necked cane-borer (*Agrilus ruficollis* Fab.): beetle, larva, and gall—all much enlarged. (After Riley.)

may throw out leaves, but they rarely ripen fruit and usually die during the season. By opening the gall it will be found that only the bark has been injured by a spiral channel which girdles the stem and causes the gall-like thickening of the bark. Above the swelling evidence will be found of the borer's work in the

* *Agrillus ruficollis* Fab. Family *Buprestidæ*. See J. B. Smith, 12th Report, N. J. Agr. Exp. Sta., p. 373; and F. M. Webster, l.c., p. 191.

pith, and from one to six inches above the gall the slender white larva will be found at work.

There seems to be considerable difference in the susceptibility of varieties, Dr. Smith observing that the "Wilson" and blackcap raspberries are badly infested, while the "Missouri Mammoth" and others were unharmed.

Life History. —The eggs are laid in June, but have not been observed. Whether laid on the stalk or on a leaf, the young larva enters the bark at the axil of a leaf-stem, and eats around the

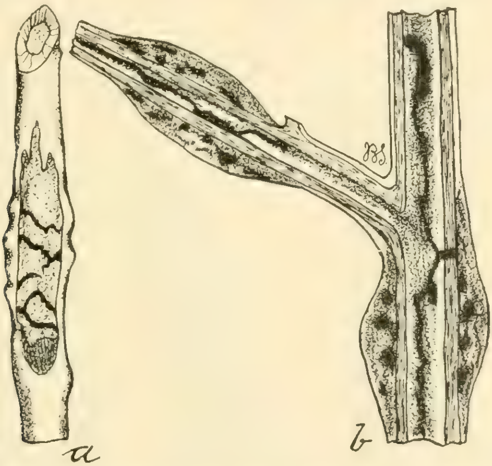


FIG. 336.—Work of the red-necked cane-borer: *a*, tracks of young larvæ, the bark sliced away to show burrows and forming gall ridges; *b*, section through galls on main cane and lateral showing track of larva through bark and pith and pupal cell. (After J. B. Smith.)

stem in a long spiral. By early August the galls commence to form where the bark has been girdled, though sometimes no gall results from the injury, and the larvæ mine into the pith. The larvæ probably become practically full grown in the fall and remain in their burrows over winter, in which they transform to pupæ in late April, in New Jersey, and the beetles emerge in late May and June. The parent beetle is not over one-third inch long, flattened, with a small wide head, and tapers at the tip of the abdomen. It has brownish-black wing-covers with a bronzy lustre, and the neck and thorax are coppery-red or brassy. The

full-grown larva is five-eighths to three-quarters inch long, with a small brown head, a much-expanded prothorax which looks like the head, and a slender, cylindrical, white body, surmounted by two slender brown horns at the tip of the abdomen.

This cane-borer is a native pest, very common in wild raspberries and blackberries, and occurs generally throughout the country.

Control.—Obviously it may be readily controlled by cutting off the infested canes below the galls and burning them. This should be done any time before May. Where wild canes are infested near those cultivated they should be included in the pruning.

The Blackberry Gall-maker *

The so-called "pithy gall" of the blackberry is an elongated,

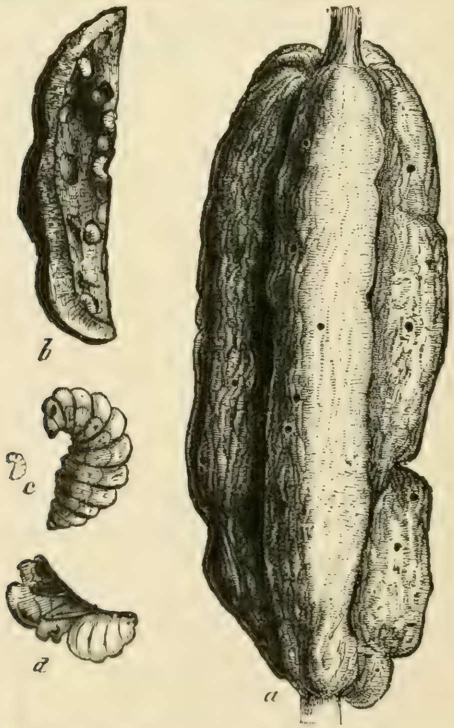


FIG. 337.—The pithy-gall of the blackberry: *a*, gall; *b*, section of same showing larvæ in cells; *c*, larva enlarged and natural size; *d*, pupa. (After Riley.)

* *Diastrophus turgidus* Bass. Family *Cynipidæ*.

pithy swelling from one to three inches long and nearly an inch in diameter, red or reddish-brown, with the surface divided by deep longitudinal furrows into four or five ridges or parts. The gall is caused by the larvæ of a small black gall-fly, which is about one-twelfth inch long, with red feet and antennæ and four transparent wings, almost lacking wing-veins. The insect passes the winter in the larval stage in the galls, and if one be opened at that season, there will be found about the middle a number of cells about one-eighth inch long, each of which contains a single larva. The larva "is about one-tenth inch long, white, with the mouth-parts reddish, and the breathing pores and an oval spot on each side behind the head of the same color." They change to pupæ in spring and the flies appear a little later. Though this gall is also very common on wild canes it rarely does much injury.

Control.—The affected canes should be cut and burned during the winter.

The Raspberry-cane Maggot *

The tips of young raspberry shoots sometimes droop and wilt in the spring in much the same manner as when affected by the cane-borer later in the season, and though blackberry shoots are similarly affected they usually recover, but bear small gall-like swellings like those shown in Fig. 339. This is the work of a small white maggot, nearly related to and looking much the same as the cabbage-maggot (p. 347), which girdles the inner bark of the stem. Injury has been observed in New York, Canada, Michigan, Pennsylvania, and recently it has become a serious pest in Washington, so that it is undoubtedly much more widely distributed than the records indicate. The parent fly, shown in Fig. 338, is grayish black, much resembling the house-fly, but slightly smaller.

Life History.—The flies appear in April and deposit their eggs as soon as the shoots are well above ground, continuing until early

* *Phorbia rubivora* Coquillet. Family *Anthomyidæ*. See Slingerland, Bulletin 126, Cornell Univ. Agr. Exp. Sta., p. 54; W. H. Lawrence, Bulletin 62, Wash. Agr. Exp. Sta.

June. The white egg (Fig. 338, *c*) is elongate, about one-fifteenth inch long, and is laid in the axil of a young leaf at the tip of a shoot (Fig. 338, *d*). The egg hatches in a few days, and the little

FIG. 338.—The raspberry cane-maggot (*Phorbia rubivora* Coquillet): *a*, adult female fly; much enlarged; *b*, raspberry shoots girdled by the maggot, natural size; *c*, egg much enlarged; *d*, tips of shoots each bearing an egg in natural position in the leaf axils, natural size. (After Slingerland.)

maggot burrows into the pith of the shoot, leaving a conspicuous entrance hole, which becomes blackish. It tunnels downward, making a small tortuous channel, and after boring for a few days about half way down the shoot, it works its way out to just beneath the bark and tunnels around the shoot, often in a spiral, so as to completely girdle it, and usually eats a small hole through the bark at this point. The maggot continues to feed on the pith at this point so as to nearly sever the shoot, the tip of which soon wilts and droops, turning a deep blue color. On blackberry shoots, however, the bark is so thick that although the tip droops

Fig. 339.—Gall-like swelling on living blackberry canes caused by the raspberry cane-maggot. (After Lawrence.)

for a few days, it usually revives and the girdling forms a circular, gall-like swelling, though even blackberries are often killed. Affected shoots usually branch from below the girdled point, making a bushy growth. Lawrence states that later in the season lateral shoots are also attacked. He also observes that maggots never develop in living canes. The maggot continues to burrow downward in the pith and becomes full grown in June, when it pupates at the lower end of the burrow. The puparia are to be found in the lower part of the affected stalk in June and July, but the adult flies do not emerge until the next spring.

Control.—As soon as the young tips are seen to droop they

should be cut off several inches below the girdled point and burned. This may be done best late in May or in June after all the eggs are laid.

The Raspberry Saw-fly *

Occasionally raspberry leaves, as well as those of blackberry and dewberry, are skeletonized in May by small green, spiny saw-fly larvæ, which sometimes quite defoliate the plant. Such injury has been commonly noted in the Eastern and Central States. The adult female is a typical saw-fly about one-quarter inch long and with a wing expanse of one-half inch. The body and wings are black except the second to sixth abdominal segments, which are yellowish-white, and the under side is rusty. The male is somewhat smaller and is entirely black except the shoulders, which are yellowish-white.

Life History.—The adults appear about the middle of May in central New York, and the females deposit their eggs late in that month. The eggs are inserted just under the cuticle of the under surface of the leaf, and the tissue around them turns yellowish, so that infested leaves soon become spotted on the upper surface. The egg is nearly pear-shaped, yellowish-white, about one-twentieth inch long, and hatches in seven to ten days. As many as twenty-four eggs have been observed in a single leaf, and frequently the leaves are so spotted as to be readily recognized. The young larva is about one-twelfth inch long, yellowish-white or pale yellowish-green and well covered with spiny tubercles, the spines being first white and later dark brown. The young larvæ feed on the soft parts of the leaf, but as they grow older all but the midrib and larger veins are devoured. The mature larva is about three-quarters inch long, from light yellowish-green to dark green, closely simulating the color of the foliage, and the body is covered with transverse rows of tubercles, bearing a varying number of strong, barbed spines, which are dark brown on the back and pale green or white along the sides. The larva feeds for about ten

* *Monophadnus rubi* Harris. Family *Tenthredinidæ*. See V. H. Lowe, Bulletin 150, N. Y. Agr. Exp. Sta.

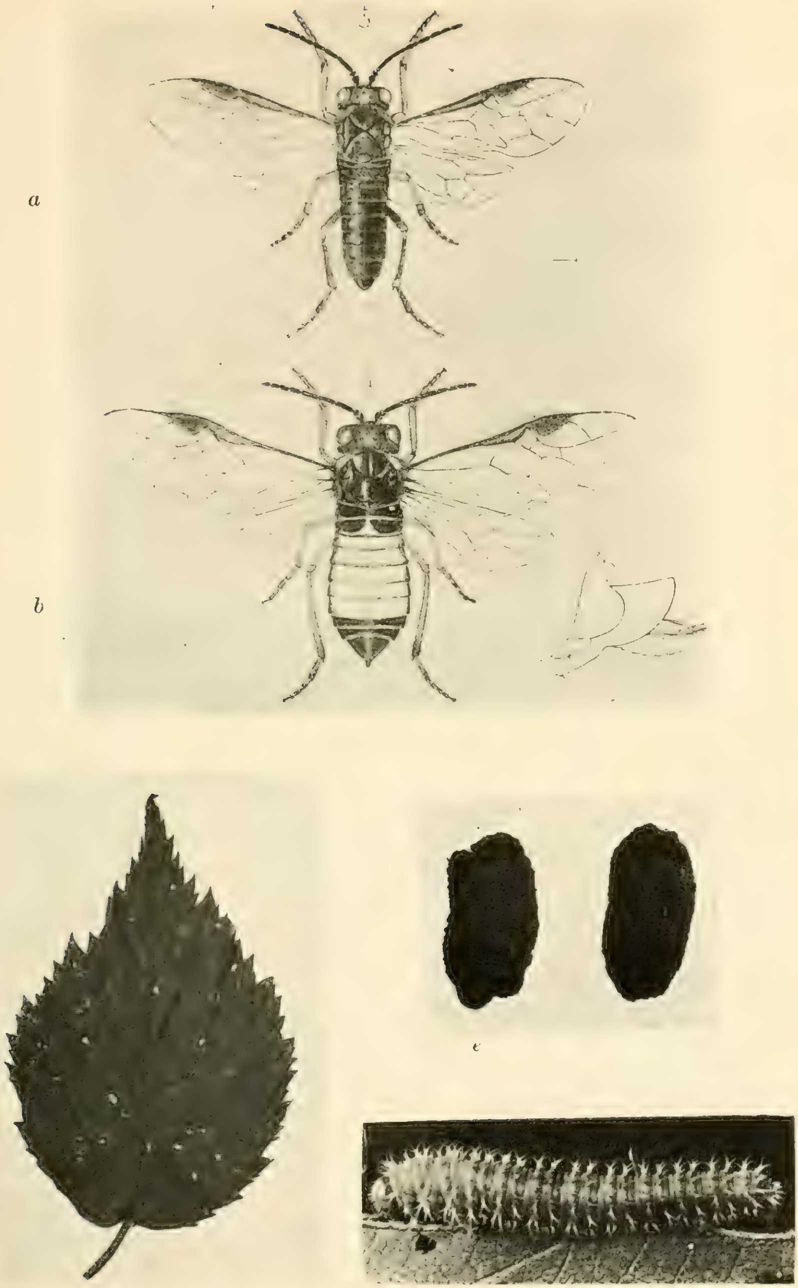


FIG. 340.—The raspberry saw-fly (*Monophadnus rubi* Harr.): *a*, male; *b*, female; *c*, egg blisters on leaf; *d*, larva; *e*, cocoons—all much enlarged. (After Lowe.)

days and then enters the soil for from two to three inches and there constructs a small oval cocoon about one-third inch long, which looks like a pellet of earth, being formed of a brown mucilaginous substance, interwoven with coarse strands of silk, to which particles of earth adhere. The larva then hibernates until the next spring, when it transforms to the pupa and in a few days the adult appears, usually early in May.

Control. — By suddenly jarring or shaking the bushes the larvæ will drop to the soil. On light soils this habit may be utilized for their destruction by jarring them to the ground and following with cultivators so as to bury the larvæ in the loose soil. This will be particularly applicable in hot weather, if the soil is hot and dusty, when most of the larvæ will be killed before regaining the plants. By frequent cultivation in late summer or fall the cocoons might be brought to the surface and some of the larvæ might be thus killed during the winter, though this needs testing, as they are fairly well protected. The larvæ may be readily killed with arsenical sprays, and if arsenate of lead were applied at the rate of 3 pounds per barrel just as the plants commence to flower, it would undoubtedly control the pest with no possibility of spotting the fruit, or Paris green with Bordeaux mixture might be used in the same way. If careful watch is kept for the pest it can probably be detected in time to apply the arsenicals, which will be much the easiest and most effective to use, but if not observed until the canes are fruiting they should be sprayed with hellebore, 1 ounce to 1 gallon of water. Hellebore may be dusted on the plants mixed with twice its weight of flour, but the spraying may be done more thoroughly.

The Raspberry Byturus *

The Raspberry Byturus is a small brown beetle belonging to the same family as the larder and carpet beetles, most of which feed on animal matter. It is about one-seventh inch long, reddish-yellow or reddish-brown, and covered with a thick coat

* *Byturus unicolor* Say. Family *Dermestidæ*. See W. H. Goodwin, Bulletin 202, Ohio Agr. Exp. Sta.

of pale, tawny hairs. The beetles appear about the middle of May in northern Ohio. They feed on the tender foliage and eat into the flower buds, and sometimes emerge in such numbers that the young foliage is skeletonized and many of the flower buds do not develop. Though the eggs are laid in June, they have not been observed. The larvæ appear in late June and July

FIG. 341. — Larva and adult of the raspberry byturus—enlarged. (After Goodwin.)

and feed in the fleshy head on which the berry is born, causing the affected berries to ripen earlier, making them small and unfit for market. Furthermore the little larvæ not infrequently

FIG. 342.—Early ripening berries, the smaller ones infested with Byturus larvæ. (After Goodwin.)

remain in the cup of the berry, which necessitates picking teh berries over and injures their sale. The larva is about one-

quarter inch long, rather plump and cylindrical, and tapering at each end. The body is white, but each segment is marked across the back with a broad, tawny yellow band, and numerous short white hairs. When full grown the larva drops to the ground and forms an earthen cell just beneath the surface, in which it transforms to a yellowish pupa, from which the beetle emerges the next spring. Only red raspberries seem to be affected, and some varieties are particularly injured. The insect has been reported as injurious from Minnesota to Massachusetts and in Ontario.

Control.—Inasmuch as the beetles feed freely on the foliage before ovipositing they may be destroyed by spraying the leaves with arsenate of lead. Mr. Goodwin has shown that where foliage was sprayed with 4 pounds per barrel, that three-fourths of the subsequent injury to the berries by the larvæ was prevented by the destruction of the beetles, and the injury to the flower buds was also lessened. Thorough cultivation in the fall close around the bushes will probably destroy many of the pupæ by exposing them to winter weather.

CHAPTER XXIV

INSECTS INJURIOUS TO THE CURRANT AND GOOSEBERRY

The Imported Currant-borer *

One of the worst pests of the currant and gooseberry is the borer, which tunnels out the canes and where abundant frequently kills the plants. It is a European insect which has spread to all parts of this country where these fruits are grown. The adult is one of the clear-winged moths and with the larva is very

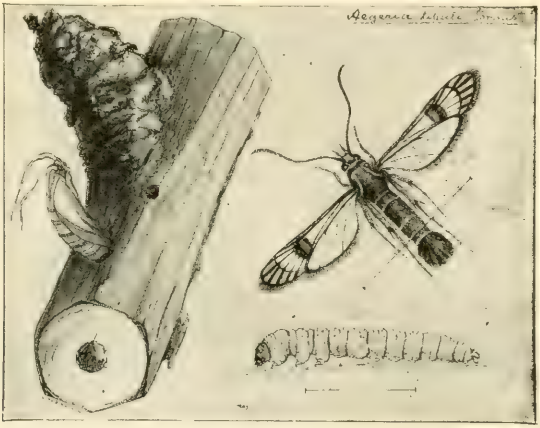


Fig. 343.—The imported currant-borer (*Aegeria tipuliformis* Clerck): moth, larva, and empty pupal skin left protruding from burrow. (After Lugger.)

similar in appearance and habits to the raspberry root-borer (p. 459). The moth is about one-half inch long with a wing-expanse of three-quarters inch. The body is black with a steel-blue lustre, with a bright yellow band around the neck and three

* *Ægeria tipuliformis* Clerck. Family *Sesiidæ*. See Lugger, 1st Report Minn. State Entomologist, p. 184.

yellow bands across the abdomen, which bears a large tuft of long scales at the tip. The wings are clear except for a margin of blackish scales and a band across the fore-wings about one-third from the tip.

Life History. The moths appear in June and deposit their small globular, brown eggs in the axils of the leaves next the canes, or under scales or in cracks of the canes. The young caterpillars bore into the pith of the canes, which they tunnel out, and are about half grown by winter, when they descend to the bottom of the burrows and hibernate. In the spring they continue their work and become full grown by May. The full-grown larva is slightly over one-half inch long, of a yellowish color, with brown head, and with numerous small tubercles over the body. It cuts a hole through the side of the burrow, which it closes with small chippings, and then transforms to the pupa. When the moth is ready to emerge the pupa wriggles itself partly out of the burrow by means of the strong spines on the abdomen, and the moth comes forth. Affected canes can be recognized by the dwarfed and yellow foliage and the general unhealthy appearance of the plant, and if not removed will usually die during the season.

Control.—The only method of control is to keep all the old wood removed and to cut out and burn all affected canes in fall or early spring, whenever the injury may best be detected.

The Currant-stem Girdler *

In late spring, after the young currant-shoots have reached a growth of several inches, two or three inches of the tips sometimes wilt, and fall over and hang suspended or drop to the ground. If examination shows that the tip has been girdled by several sharp cuts, it is probably the work of the Currant-stem Girdler. It is a native insect which was first described from Massachusetts, and has also been found injurious in Rhode Island, Canada, Ohio

* *Janus integer* Norton. Family *Tenthredinidæ*. See Slingerland, Bulletin 126, Cornell Univ. Agr. Exp. Sta.; F. H. Chittenden, Bulletin No. 46, Bureau of Forestry, pp. 68–70.

FIG. 344.—The currant stem-girdler (*Janus integer* Norton): *a*, female at work girdling a currant stem— natural size; *b*, girdled portion of stem much enlarged to show character of girdle; *c*, stem cut open to show egg; *d*, egg—much enlarged. (After Slingerland.)

and Michigan, but has been most troublesome in New York. It has also been noted as a pest of willow and poplar in Maryland, and of basket willow in Kentucky, Indiana, and Ohio, so that it is doubtless quite generally distributed. The adult insect is a slender saw-fly with shining black body and light brownish legs, shown natural size in Fig. 344*a*. The male is smaller and has a brownish-yellow abdomen, while in the female the first half of the abdomen is reddish-orange and the rest is black. The adults are abroad in May, but are very shy and are seldom seen.

Fig. 345.—Currant stem girdled by the stem-girdler. (After Slingerland.)

They are saw-flies in the truest sense of that term, for the female makes most effective use of her saw-like ovipositor, as has been very interestingly described and illustrated by Professor Slingerland. The ovipositor is thrust into the cane for its whole length, and through it the egg is deposited in the pith. The egg is an elongate-oval shape, yellowish-white, and about one-twenty-fifth inch long (Fig. 344*d*). Immediately the female moves an inch or two higher and girdles the stalk by numerous thrusts of her ovipositor, which is thrust in and then given a twist to one side so that it comes out at one side of where it was forced in, and makes a horizontal cut. The eggs are laid in late May and early

June and hatch in about eleven days. The young larvæ bore into the pith, but the tunnel rarely extends over six inches below the point girdled. The full-grown larva is hardly one-half inch long, of a glistening straw-yellow color, with darker head. The thoracic segments are wider than the others and bear rudimentary feet, and from the tip of the stout, cylindrical abdomen projects a horny, brown bifid spine. In the fall the borer cleans out its burrow at the lower end and eats a hole through the woody wall of the stem to the outer bark, which sinks in at this point. The grub then spins a thin silken cocoon about itself, in which it hibernates over winter, transforming to a whitish pupa in April, from which the adult emerges early in May. The girdling of the stalks is the principal injury, and those which harbor the pest may be recognized, even in winter, by the characteristic dead stubs, cut off squarely at the upper end.

Control.—The drooping of the tips in May is soon noticed and during June they should be cut off about three inches lower down and burned, or if the pruning is left until winter the infested stubs should be cut off about eight inches below the point girdled, as the larvæ rarely tunnel deeper.

The Four-lined Leaf-bug *

This is one of our most common leaf-bugs, which has a long list of food plants, but is particularly injurious to the young foliage of currant and gooseberry. The adult bug is easily recognized, as the upper surface is a dark green with four stripes and the tips of the wing-covers black, as shown in Fig. 346. The green changes to yellow after death and the body is bright orange-yellow, and the legs green. The " presence of the pest is indicated by the appearance of the peculiar brown depressed spots on the tender terminal leaves " in early summer. " As the attack continues, whole leaves turn brown, curl up, become brittle, and are torn or broken by the wind. The young shoot is checked and frequently droops and dies. The buds of dahlias and roses are

* *Pœcilocapsus lineatus* Fab. Family *Capsidæ*. See Slingerland, Buletin 58, Cornell Univ. Agr. Exp. Sta.

often blasted." Slingerland gives a list of some fifty-seven food-plants, including all sorts of crops, ornamental plants and weeds. Parsnip, mint, sage, rose, deutzia, dahlia, and others are often badly injured. The species has been observed from Canada to Georgia and westward to the Dakotas, so that it is probably generally distributed east of the Rockies.

Life History.—The nymphs hatch from the overwintering eggs in late May and early June and are very largely responsible for the injury to the foliage. The newly hatched nymph is only

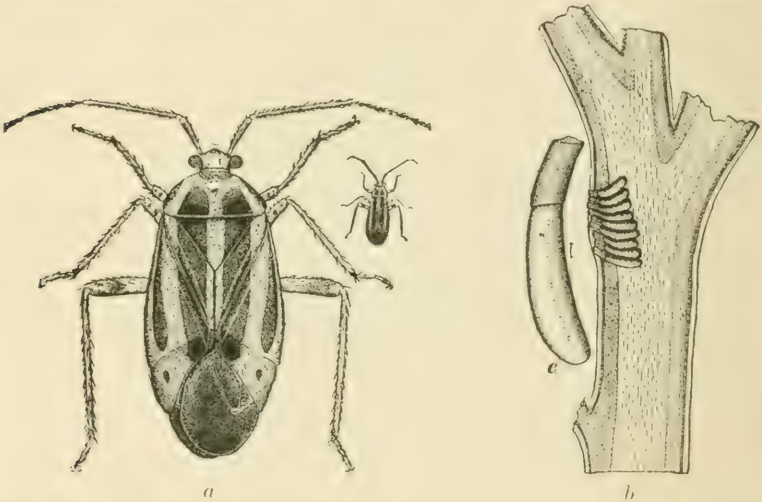


FIG. 346.—The four-lined leaf-bug (*Pœcilocapsus lineatus* Fab.): *a*, adult; *b*, cross-section of stem showing eggs in position and a single egg greatly enlarged. (After Slingerland.)

about one-twentieth inch long, but is easily recognized by the shining vermilion-red color of the body, marked with large blackish spots on the thorax and with greenish-black antennæ and legs. The nymphs grow rapidly, becoming full grown in seventeen to twenty days after hatching, during which time they have molted five times. The full-grown nymph is about one-fifth inch long, bright orange yellow, and the black wing-pads extend half way to the end of the abdomen and bear a yellowish green stripe near the outer margin. The nymphs feed on the tenderest young leaves, sucking out the juices and soft tissue through their tiny

beaks, and thus causing the spots mentioned. " As the nymphs increase in size the spots are a little larger and more numerous, until not only hundreds occur on a single leaf, but often nearly all the parenchyma is taken from the leaf." The nymphs are very active and dart from one side of the leaf to the other when disturbed. The adult bugs appear about the middle of June and are active for a month or more, when they disappear. They mate and the females commence to lay eggs about a week after

FIG. 347.—Currant leaf spotted by the nymphs of the four-lined leaf-bug. (After Slingerland.)

they first appear. The female is furnished with a strong ovipositor with which she inserts the eggs in slits cut lengthwise into the stems of the plants extending nearly half way through the pith. A half-dozen or more eggs are packed together in the small slit, which may be one-eighth inch long. The individual egg is about one-sixteenth inch long, light yellow, and shaped as in Fig. 346*e*, with the upper third capped by a white, finely striated portion. " With the growth of the surrounding tissue of the stem, the eggs

are usually forced out of the slit somewhat, so that about one-half . . . of the white portion of the egg projects from the slit." Most of the slits are made two or three inches, rarely over six inches, below the tender tips.

Control.—Experiments indicate that the nymphs may be killed by spraying them with kerosene emulsion containing 10 per cent kerosene. Tobacco extracts should also be tried. The

Fig. 348. Currant leaves killed by the four-lined leaf-bug. (After Slingerland.)

adults are not susceptible to this treatment, however. Both nymphs and adults will drop from the foliage when disturbed, and Professor Slingerland has suggested that they might be jarred into a pan of kerosene. By drawing pans, such as constructed for combating the pea-aphis (p. 326), between the rows and jarring the bugs into them, many might be destroyed. As the eggs are readily recognized, the tips containing them should be cut off and destroyed during the winter.

The Currant-aphis *

The young foliage of currants, and sometimes of gooseberries, is often found curled up in late spring with many bladder-

* *Myzus ribis* Linn. Family *Aphididæ.* See V. H. Lowe, Bulletin 139, N. Y. Agr. Exp. Sta., p. 660. Another species, *Rhopalosiphum ribis* Linn., is also common on currant and is described and figured by Mr. Lowe.

like galls on the leaves, inside of which are found the numerous yellowish-green plant-lice which have caused them. The wingless females are about one-twelfth inch long, yellowish-green or green, mottled with darker shades, and with bright red eyes. The winged female is slightly longer, with wings expanding one-third inch. It is bright greenish-yellow, with pale olive head, thoracic lobes brown, and the abdomen is marked by several dark transverse bands and lateral spots. It is an old European

Fig. 349.—Currant foliage curled by aphides. (After Lowe.)

species and is probably found throughout the United States where currants are grown.

Life History.—The life history is practically the same as that of several other aphides previously described and need not be rehearsed in detail. The small black eggs are found on the stalks in winter and hatch just as the foliage appears. The aphides multiply on the foliage, causing it to curl as described, until midsummer, when they either migrate to some other food-plant or become greatly reduced in numbers through the attacks of parasites and predaceous insects, which are very effective in the control of this species. Mr. Lowe states that a few females may be found on the foliage throughout the summer. In late October

winged males appear and mate with the true females, which then lay the eggs.

Control.—The aphides may be readily killed by spraying with kerosene emulsion, whale-oil soap, 1 pound to 6 gallons of water, or tobacco extracts, but the spraying must be done before the foliage becomes badly curled. Ordinarily they may be held in check by picking off the curled leaves by hand.

The Imported Currant-worm *

"The most destructive insect that attacks the currant," says Professor Lugger, "is the above-named saw-fly, which feeds

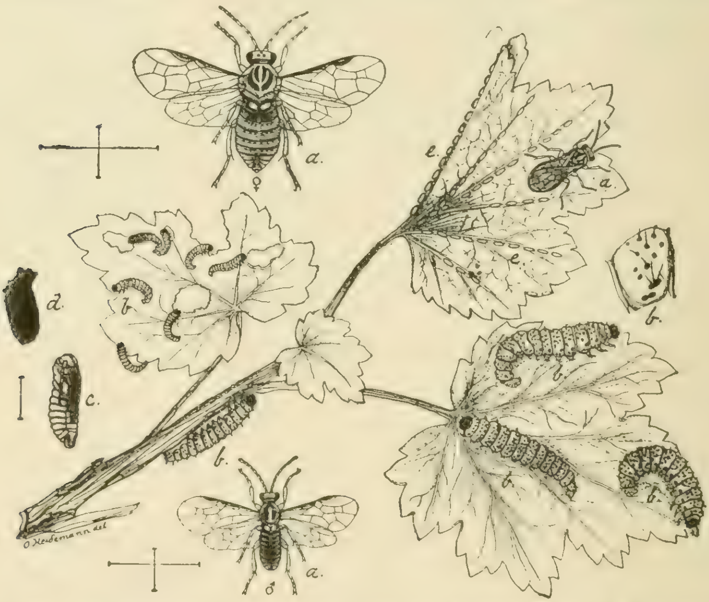


FIG. 350.—The imported currant-worm (*Pteronus ribesii* Scop.): *a*, male and female saw-flies; *b*, larvæ; *c*, pupa; *d*, cocoon; *e*, eggs—all enlarged. (After Lugger.)

indiscriminately on all kinds of currants and gooseberries. The imported species is supposed to have been accidentally introduced

* *Pteronus ribesii* Scop. Family *Tenthredinidæ*. See Lugger, Bulletin 43, Minn. Agr. Exp. Sta., p. 179; C. L. Marlatt, Bulletin 3, Tech. Series, Div. Ent., p. 61.

into this country about the year 1857, and has since spread over the greater part of the United States and Canada. The eggs are glued to the main-ribs of the leaf as shown in Fig. 350, and not inserted into pockets, as is usually the case with saw-flies. . . . In from four to ten days the egg hatches into a very small whitish caterpillar with a white head and ornamented with black spots on each side. This color, however, changes to green as soon as the caterpillars begin to feed, and after their first skin is shed, the head becomes black and many black spots appear on the body. This coloration persists until the last molt when the insect becomes grass-green. The head, however, retains the black spots on each side. The length of the worm is now about three-fourths of an inch. While growing they at first skeletonize the leaves; later they eat the entire leaf, with the exception of the ribs, and at last they devour immense quantities of them, often completely stripping the bushes of their foliage. If this is repeated year after year, the plants produce less and less fruit and eventually die. The larvæ now descend to the ground, in which they spin a small, oval cocoon of brownish silk, either just below the surface of the ground or among the leaves and rubbish that collect below the plants. Inside these cocoons they change to pupæ and later to adults, which are ready to issue as winged saw-flies during the last of June or in July (in Minnesota), sometimes not until the first of August. They now pair and produce a new generation of injurious worms . . ., the adults of which do not, however, issue until the following spring. As the two broods overlap, we can find larvæ of all stages during the greater part of the summer." The adult saw-flies are well illustrated in Fig. 350. The female is about one-third inch long, of a light yellowish color marked with blackish as shown in the figure, while the male is smaller and rather darker.

Control.—See page 488.

The Native Currant-worm *

The native currant-worm is not usually so destructive as the European species, but occasionally becomes injurious and is

* *Gymnonychus appendiculatus* Hartig. Family *Tenthredinidæ.*

widely distributed, occurring from New England to Minnesota and Colorado, in British Columbia, and probably in the Pacific States. The larva is about two-thirds the size of the imported species, but is uniformly pale-green except the head which is black until the last molt, after which it becomes partly green. One generation of larvæ appears in late June and another in August. The cocoons are usually attached to the twigs or leaves of the bushes. The female saw-fly is dull black with dull yellow head, and honey-yellow legs.

Control.—While fruiting the foliage should be dusted or sprayed with hellebore, which is the time-honored remedy for currant-worms (p. 47). However, before the fruit has set and after it is picked, spraying with arsenicals will be much cheaper and more effective, and as it is often desirable to spray gooseberries for diseases with Bordeaux mixture, by adding arsenate of lead or Paris green to it, the worms may be easily controlled.

The Currant Span-worm *

The Currant Span-worm is readily distinguished from the other currant "worms," by being one of the measuring-worms or inch-worms which loop along as shown in Fig. 351. It is not frequently very destructive, but occasionally becomes a pest, more particularly of black currants and gooseberries, throughout the eastern half of the country. The caterpillar is slightly over an inch long when full grown, and of a whitish color with a wide yellow stripe down the back, another along each side, and several black spots on each segment. The under side is white with a slight pinkish tinge, with a broad yellow median stripe, and is also spotted with black. The moth has a wing expanse of about $1\frac{1}{4}$ inches, is a pale yellowish color, with several brownish spots, varying in size and sometimes forming one or two irregular bands across the wings.

Life History.—The eggs (Fig. 351*a*) are laid in midsummer on

* *Cymatophora ribearia* Fitch. Family *Geometridæ*.

the twigs of the infested plants and hatch as the bushes come into full leaf the next spring. The caterpillars become full grown in three or four weeks, when they pupate just beneath the surface of the soil, and two or three weeks later the moths emerge.

Control.—Hellebore is not as effective as against the saw-fly larvæ and as the larvæ usually appear before the fruit is setting, they may be better controlled by spraying with arsenicals. When

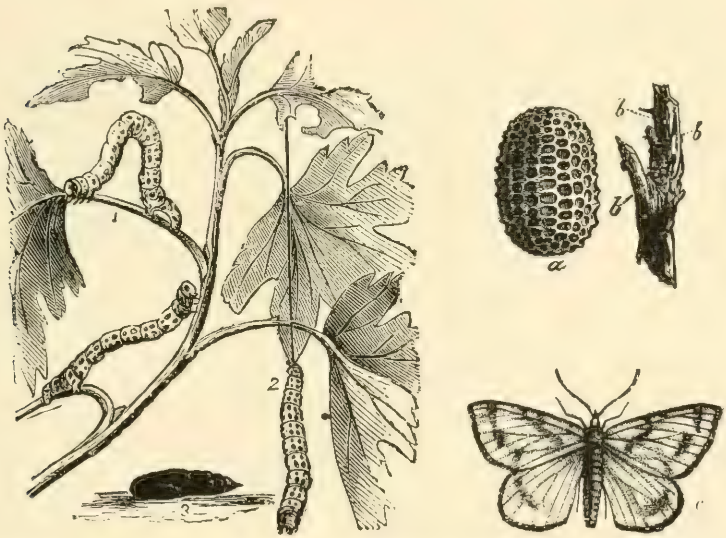


FIG. 351.—The currant span-worm (*Cymatomorpha riberia* Fitch): 1, 2, larvæ; 3, pupa; *a*, egg; *b*, eggs on twig; *c*, moth—*a*, much enlarged, others natural size. (After Saunders.)

the caterpillars are disturbed they drop from the foliage, letting themselves down by a silken thread and remaining suspended in mid-air until danger is over, when they reascend the thread. This habit may be utilized for their destruction by jarring the bush so that they will drop, and then passing a forked stick around it so that all the threads may be caught and the caterpillars may be drawn out in groups and crushed with the foot.

The Currant-fly *

Currants and gooseberries sometimes turn red and drop prematurely, due to the injury of small maggots which may be found within them. The insect has been troublesome in Maine and is sometimes a serious pest in Colorado. It is a native insect and is probably generally distributed throughout the northern United States and southern Canada. The adult fly is about the size of a house-fly, a pale yellowish or yellowish-brown color, with dark

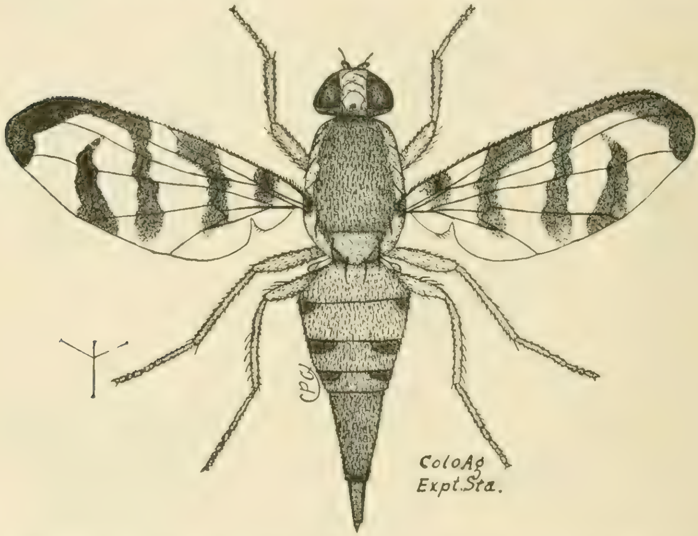


FIG. 352.—The currant-fly (*Epochra canadensis* Loew.)—much enlarged. (After Gillette.)

bands across the wings, and a tapering abdomen, as shown in Fig. 352.

Life History.—The flies appear in late spring and the females deposit their eggs in the older berries. A female will lay about 200 eggs during the period of a month, placing but one in a berry, so that a single fly may do considerable damage. The white egg is about one-twenty-fifth inch long and laid just under the skin,

* *Epochra canadensis* Loew. Family *Trypetidæ*. See F. L. Harvey, Bulletin 35, Maine Agr. Exp. Sta.

where it is easily seen. The egg hatches in a few days into a small white maggot, which burrows around the berry and then feeds upon the seeds. The location of the larva may be seen, as the infested currant soon shows a clouded appearance and finally turns red and a black spot appears. The maggot becomes full grown in about three weeks and then eats its way out of the berry, which has usually fallen to the ground. The mature maggot enters the soil for about an inch and there changes to the pupa, from which the fly emerges the next spring.

Control.—As the maggots usually remain in the berries a few days after they drop, all fallen berries should be frequently picked up and destroyed. Poultry running among the bushes will do this very effectually. Other methods will suggest themselves from the above life history, but none seems to have been carefully tested.

CHAPTER XXV

INSECTS INJURIOUS TO THE GRAPE *

The Grapevine Phylloxera †

This insect is native east of the Rocky Mountains, where it has always lived upon wild vines and did not attract attention until it was imported into France about 1859, as it does practically no damage to the native American grapes. It soon spread through the principal wine districts of southern Europe, where it caused

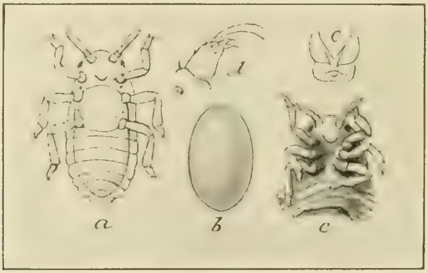


FIG. 353.—The grapevine phylloxera (*Phylloxera vastatrix* Planchon): *a*, true sexual female, the dark colored area indicating the single egg; *b*, egg; *c*, shrivelled female after oviposition; *d*, foot of same; *e*, rudimentary and functionless mouth-parts. (After Marlatt, U. S. Dept. Agr.)

immense losses and the temporary abandonment of vineyards, due to the fact that the European varieties are very susceptible and readily succumb to injury by it. It has spread to southern Russia and the adjoining countries of Asia and Algeria, and has been carried to New Zealand and South Africa. In this country

* See A. L. Quaintance, Farmers' Bulletin 284, U. S. Dept. Agr.; H. J. Quayle, Bulletin 192, Cal. Agr. Exp. Sta.; F. Z. Hartzell, Bulletin 331, N. Y. Agr. Exp. Sta.

† *Phylloxera vastatrix* Planchon. Family *Aphididæ*. See C. L. Marlatt Farmers' Bulletin 70, U. S. Dept. Agr., and Quayle, l. c.

it is injurious only in California, where it was imported on French vines about 1874. It was first noticed in Sonoma County and since then has spread to all the principal grape-growing regions north of Tehachapi and has probably destroyed 50,000 acres.

This aphid exists in several forms, which injure both foliage and roots. On the leaves irregular spherical galls are produced, and the root-inhabiting form produces galls on the roots. The leaf-galls are very common on American grapes, but are no indication of the presence of the root form, as the roots are rarely injured where the foliage is covered with leaf-galls. On the other hand the European varieties rarely exhibit any leaf-galls, but are

FIG. 354.—Under side of grape leaf showing galls caused by Pyylloxera. (After Riley.)

very susceptible to the root phylloxera, which multiplies without any external indication of its presence until the vine is seriously injured. The injury to the vine is not due so much to the sap taken from the vine by the myriads of aphides which may inhabit the roots, as to their poisonous effect on the root tissue and its subsequent decay. Wherever the phylloxera attack the roots, small swellings are produced, composed of soft tissue, which soon decays. When such a gall is formed at the end of a young root, its growth is stopped, and on larger roots a decay sets in which finally girdles the root and all below the injured point dies. As

all the roots become affected the vine stops growing, the leaves become sickly and yellowish, and the vine dies, and the phylloxera disappears from the rotting roots, so that the cause of the injury would be obscure were the nature of the injury not known.

Life History.—The life history of the phylloxera is a complicated one, involving four different forms of aphides; the leaf-gall form, the root or destructive form, the winged or colonizing form, and the sexual form. The winter eggs are deposited on the rough bark of the old wood in the fall and hatch the following

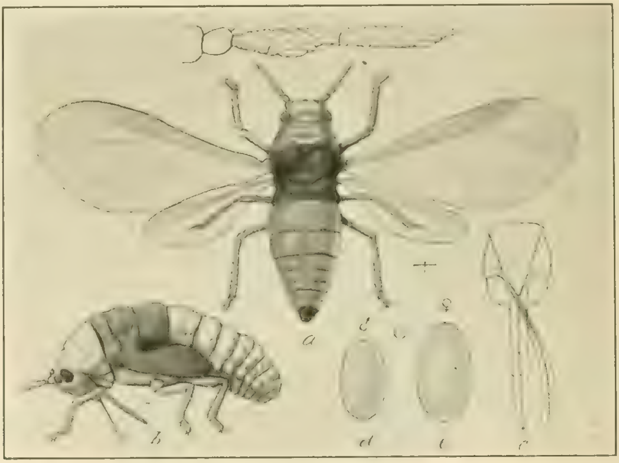


FIG. 355.—The grapevine phylloxera: *a*, winged migrating female; *b*, last stage of nymph of some; *c*, mouth-parts with thread-like sucking setæ removed from sheath; *d*, and *e*, eggs of male and female, showing sculpturing—all enlarged. (After Marlatt, U. S. Dept. Agr.)

spring. The young aphides settle on the leaves, where the irritation caused by their mouth-parts soon causes a depression around each which forms a gall projecting on the lower side of the leaf. "In about fifteen days the louse becomes a plump orange-yellow, full-grown, wingless female, and fills its gall with small yellow eggs, dying soon after. The eggs hatch in about eight days into young females again like the parent, and migrate to all parts of the vine to form new galls. Six or seven generations of these wingless females follow one another throughout the summer,

frequently completely studding the leaves with galls." In California the young hatching from the winter eggs go directly to the roots where they give rise to new colonies, there being no gall forms, according to Quayle. Where the leaf-gall females occur many of them probably migrate to the roots during the summer, and all do so with the approach of cold weather. In the spring the roots are attacked and a series of generations of wingless females multiply on them. As there are five to seven generations in a season and each female lays from 30 (Quayle) to 100 (Marlatt) eggs, it is evident that they will soon be numerous enough to destroy the vine. The root-inhabiting females are very similar

FIG. 356.—Grapevine phylloxera: *a*, root galls; *b*, enlargement of same showing disposition of lice; *c*, root-gall louse—much enlarged. (After Marlatt, U. S. Dept. Agr.)

to those in the leaf-galls, and are about one-twenty-fifth inch long when mature and half as long when young and active. They are light greenish-yellow in summer and darker in winter, and when numerous the infested roots look as if dusted in spots with powdered mustard, according to Quayle. He states that "the newly hatched insect is fairly active, and at first moves from place to place on the roots, but finally, when it reaches the egg-laying stage, inserts its sucking-tube into the root and remains fixed." During the late summer and early fall some of the root-lice develop into winged females which escape through cracks in the soil and

fly to neighboring vines. They lay from two to four eggs beneath the loose bark on the old wood and soon die. "The eggs are of two sizes, the smaller and fewer in number yielding males in nine or ten days, and the larger the females of the only sexed generation in the whole life round of the insect. In this last and sexed stage the mouth-parts of both sexes are rudimentary, and no food at all is taken. The insect is very minute and resembles the newly hatched louse of either the gall or root form. After fertilization the single egg of the larva-like female rapidly increases in size until it fills the entire body of the mother and is laid within three or four days, bringing us back to the starting point."* The phylloxera has been distributed over the world by infested rooted plants or cuttings bearing winter eggs, and is spread locally by means of the winged females, by the escape of the young root-lice through cracks of the soil and their migration to neighboring plants, or by bits of infested roots being spread in cultivation, and by the leaf-gall lice being spread to other plants by the wind or by being carried by birds or insects.

Control.—The principal means of control lies in the use of resistant vines. These may be varieties which have proven successful in the eastern United States, where the insect is native, or more commonly the stocks of grapes from the Eastern States are grafted with the desired varieties. There is a marked variation in the resistance of different species and varieties and not all of them can be successfully used as stocks for the desired scions, so that the successful use of the method, which is fully outlined by Quayle, l.c., requires a considerable knowledge of viticulture.

Carbon bisulfide has been used very extensively for destroying the root-lice, but is expensive and is only applicable on rich, deep, loose soils. It cannot be used successfully on soils containing much clay, or on dry rocky hillsides, or when the soil is saturated with moisture, and is most effective on sandy soils where the insect is least injurious. It is applied at the rate of 125 to 250 pounds per acre at a cost of \$15 to \$25 per acre. It may be applied any time except during the blossoming and ripening of

* Quotations from Marlatt, l. c.

the fruit, two applications, one after vintage and the other just before blossoming, giving the best results. It is applied by pouring one-half to three-quarters ounce into holes a foot deep, from 18 to 24 inches apart, all over the vineyard, but not nearer than one foot to the vine. The holes may be made with an iron rod or dibble and are closed by packing the soil down with the foot as soon as the liquid is poured in. Where extensively used special injectors are used. Where the vines are much weakened they do not withstand the effect of the bisulfide, and treated vines must be thoroughly fertilized and cultivated.

One of the best methods of destroying the root-lice where water is available is by submersion. In California the best results are secured by flooding with at least six inches of water for a week or ten days as soon as the vines have ceased active growth in November. A little later two to three weeks' submersion will be necessary and in winter thirty-five to forty days. Flooding for a couple of days in midsummer seems to destroy some of the insects, but its main value is in stimulating a vigorous growth of new rootlets. Longer flooding in summer, when the aphides might be most easily destroyed, injures the vines.

On very sandy soils vines are uninjured by the phylloxera. All sandy soils are unfavorable to the pest and vines on them die more slowly, but to secure complete immunity there must be at least 60 per cent of siliceous sand. Sands containing clay or which form lumps offer less resistance.

The Grapevine Root-borer *

The larvæ of the Grapevine Root-borer feed in the old roots at some little distance from the base of the vine, and as there are no indications of the pest, its presence may easily pass unnoticed. Although not generally recognized as a serious one it has been known as a pest of the grape for fifty years, and has been observed to do considerable damage in Kentucky and West Virginia.

* *Memythrus polistiformis* Harris. Family *Sesiidæ*. See Fred E. Brooks, Bulletin 110, W. Va. Agr. Exp. Sta.

Although the vines are not killed, they are so enfeebled that they make but little growth and the crop is much curtailed. All varieties are affected in West Virginia, including the wild fox grape, *Vitis labrusca*. It is stated that in the South the Scuppernong, or southern wild fox grape, is immune from attack. The

FIG. 357.—The grapevine root-borer (*Memythrus polistiformis* Harris): male and female moths on wild lettuce leaf under grapevine—natural size. (From Brooks.)

species has been observed from Minnesota and Missouri, eastward through Ohio and Kentucky to West Virginia and North Carolina.

The parents of the borers are clear-winged moths nearly related to the peach-tree borer, currant-borer, and raspberry-borer. The females are seven-eighths inch long with wings expanding $1\frac{1}{2}$ inches. They are a dark lustrous brown color, the fore-

wings being brown and the hind-wings transparent and bordered with brown. The posterior margins of the second and fourth abdominal segments are orange or lemon-yellow, and there are spots of the same color at the bases of the wings. The males are considerably smaller than the females. The moths fly during the day and are readily mistaken for wasps of the genus *Polistes*. The males fly in a quick, wasp-like manner, and when they rest on a leaf will occasionally flutter the wings like an angry wasp, which is accompanied by a low buzzing sound, which makes the mimicry very effective.

Life History.—The eggs are laid singly on weeds, grasses or other vegetation in the vineyard or on the bark or leaves of the vines, a single female laying some 400 eggs. The egg is oval, one-twenty-fifth inch long, of chocolate-brown color, and finely pitted and sculptured. They are very readily washed off by the rain and drop to the soil, where they hatch in about three weeks. The little larvæ bore directly into the soil, wherever they may be, in search of grape roots, and may survive for several days without any food. Upon reaching a root the larva bores through the outer bark and then makes an irregular burrow in the softer parts of the bark, which may encircle the root several times. As the burrows grow larger they run with the grain of the wood, and as they are enlarged with the growth of the larva, only the outer bark is left on roots of one-half inch or less in diameter, the interior being tunnelled out and filled with the castings of the larva. Most of the larvæ feed a foot or so from the base of the vine, though one was found on a root nine feet from the base. The larvæ bore in the roots until the second fall, when they are about full grown and make cells or hibernacula, thinly lined with silk, in which they hibernate in the root. The larva becomes full grown the next spring and is then $1\frac{1}{2}$ to $1\frac{3}{4}$ inches long, of the general shape shown in Fig. 359, yellowish-white, with a small brown head, three

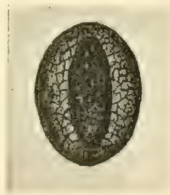


FIG. 358.— Egg of grapevine root-borer—very greatly enlarged. (After Brooks.)

pairs of brown thoracic legs, and five pairs of abdominal prolegs. When ready to pupate the larva comes near the surface of the soil and there makes a tough cocoon an inch or so long, composed of earth and excrement and lined with silk, and in it transforms

FIG. 359. Grapevine root-borers at work. Five borers were feeding in this section when taken from the ground—two-thirds natural size. (Photo by W. E. Rumsey.)

to a brown pupa with yellow bands around the abdomen. In about four or five weeks the pupa wriggles half way out of the cocoon and the moth emerges, leaving the empty pupal skin projecting above the surface of the ground. The moths emerge

in late July and early August in West Virginia and the eggs are laid in a few days. Thus the life cycle requires two full years and larvæ of two sizes may be found in the roots at any time, except during the pupal period, when all will be about half to two-thirds grown.

Control.—On account of their subterranean habits it is manifestly impossible to dig out the borers, as is done with similar species except for a few valuable vines. If the Scuppernong is as immune as has been reported, it might be used as a stock throughout the South, where it will thrive. By recognizing the parent moths, they may be destroyed by approaching them quietly when at rest and striking them quickly with a paddle or board and many might thus be killed during the time they are most abundant. By thorough cultivation in June and July many of the cocoons will be thrown to the surface or buried so deeply that many of the pupæ will be destroyed, or the adults will be unable to reach the surface. With liberal fertilization, cultivation will stimulate the vine to withstand the injury. Brooks has shown that in West Virginia the crested flycatcher (*Myiarchus crinitus*) feeds upon the moths and may be a factor in the control of the pest.

The Grape Root-worm *

The Grape Root-worm is the larva of a small, hairy, chestnut brown beetle which feeds on the upper surfaces of the leaves, eating out series of patches or holes in characteristic chain-like feeding marks which afford an easily recognizable indication of the presence of the pest in the vineyard. The larvæ devour the smaller roots and eat out pits and burrows in the larger roots, and where abundant may kill the plants in a year or two, but more commonly they cause an enfeebled growth and a consequent failure to produce profitable crops. Injury has been most severe in the grape belt

* *Fidia viticida* Walsh. Family *Chrysomelidæ*. See Quaintance, l. c.; Hartzell, l. c.; M. V. Slingerland, Bulletins 184, 208, 224, and 235, Cornell Univ. Agr. Exp. Sta.; E. P. Felt, Bulletin 19, Office State Ent. of N. Y.; Fred Johnson, Bulletin 68, Part VI, Bureau Entomology, U. S. Dept. Agr.; Johnson and Hammar, Bulletin 89, *ibid.*

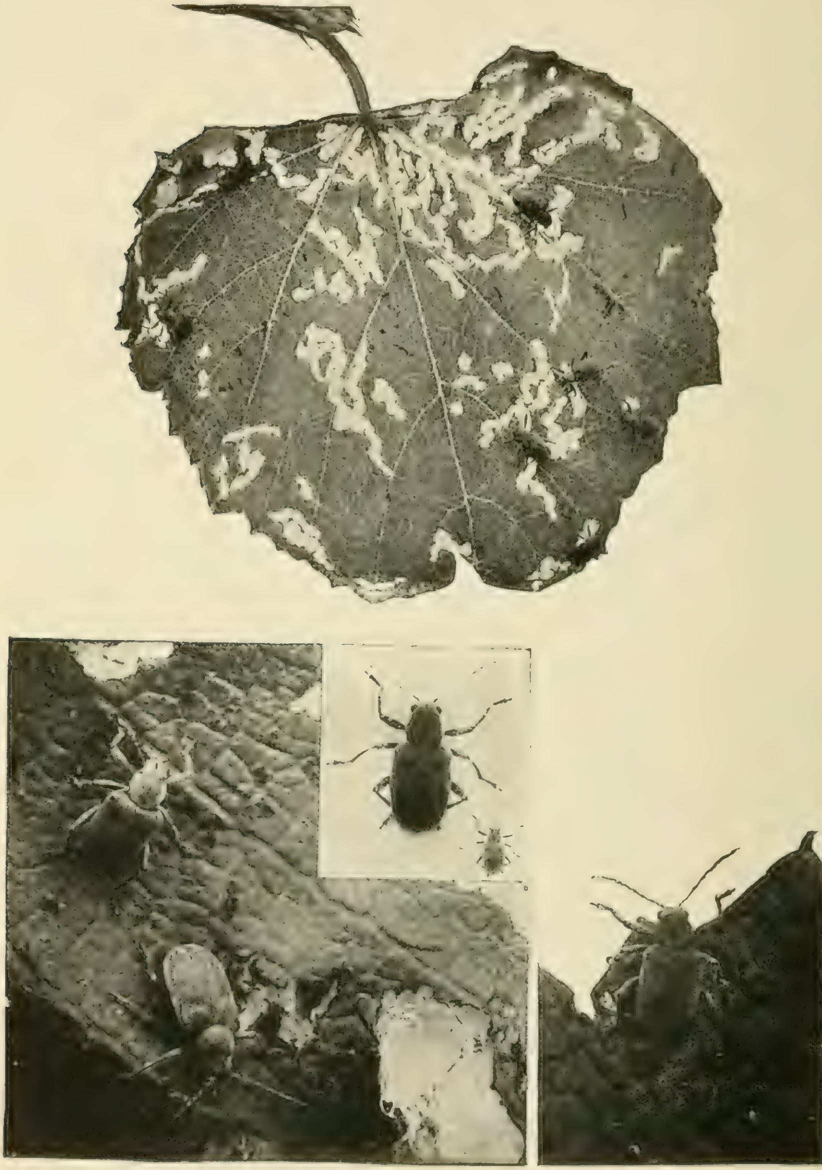


FIG. 360.—Grape root-worm (*Fidia viticola* Walsh): beetles feeding on foliage—natural size, and enlarged. (After Slingerland.)

of western New York, Pennsylvania, and northern Ohio, but the species occurs generally throughout the Mississippi Valley and the Eastern States, and has been reported from California. "The insect thrives best in vineyards which are neglected, and in the absence of cultivation and timely spraying it is likely to become

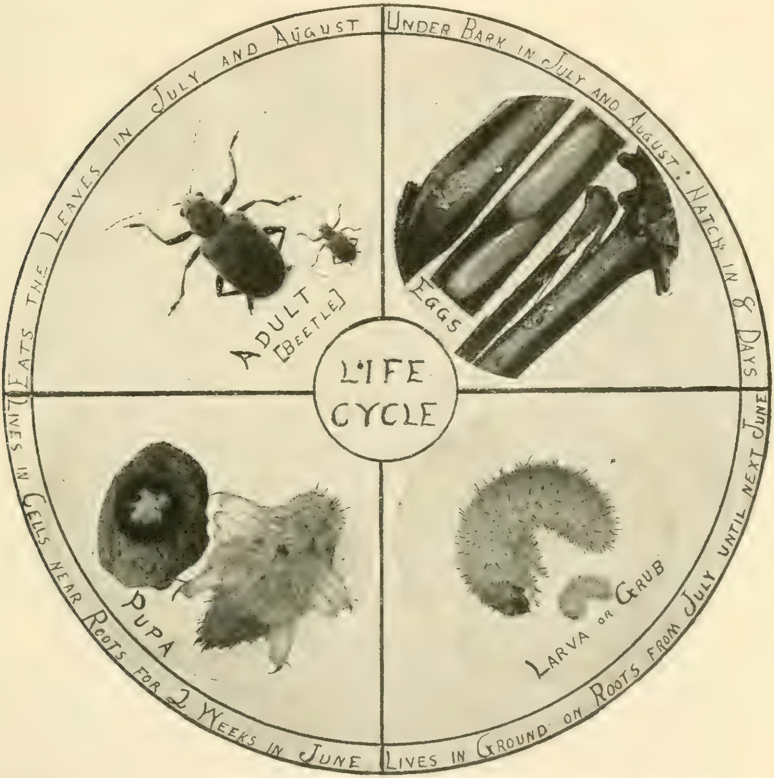


FIG. 361.—The life cycle of the grape root-worm —enlarged and natural size. (After Slingerland.)

a serious pest in any vineyard throughout its range of distribution. This is especially the case in light, sandy soils and in regions where grape growing is a considerable industry." A nearly related species,* has been known to seriously injure the foliage in Texas, but it is not known whether it affects the roots. In

* *Fidia cana.*

California, the imported grape root-worm * is sometimes destructive, has practically identical habits, and is controlled by the same methods.

The adult beetle is about one-quarter inch long, brownish in color, and covered with grayish-white hairs, with a stout body and long legs, as shown in Fig. 360. The full-grown larva is about

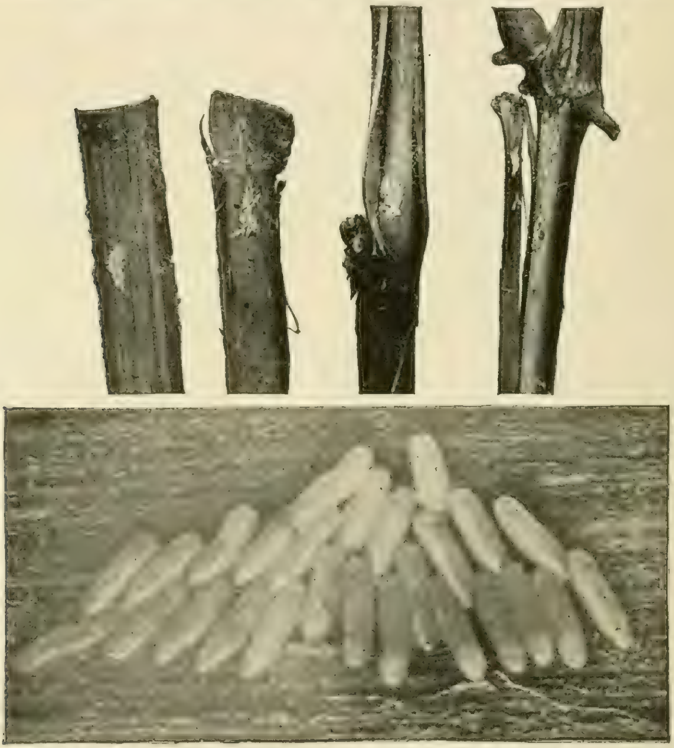


FIG. 362.—Eggs of the grape root-worm, natural size as seen on grape canes above—enlarged below. (After Slingerland.)

five-eighths inch long, whitish in color, and usually rests in a curved position as shown in Fig. 361. The head is slightly narrower than the body and yellowish-brown, as are the well-marked spiracles on the side of each segment.

* *Adoxus vitis* Fourcroy. A small shining brown or black beetle, one-fifth inch long. See Quayle, l. c.

Life History. The adult beetles appear about the close of the blooming period, or in late June and early July in the latitude of New York, and live for a month or more. They emerge earlier on warm, light sandy soils, and later on heavier soils. In a few days their feeding commences to be noticed on the leaves and the females may be found laying their eggs. A female will lay from 150 to 900 eggs, averaging about 175, most of which are laid

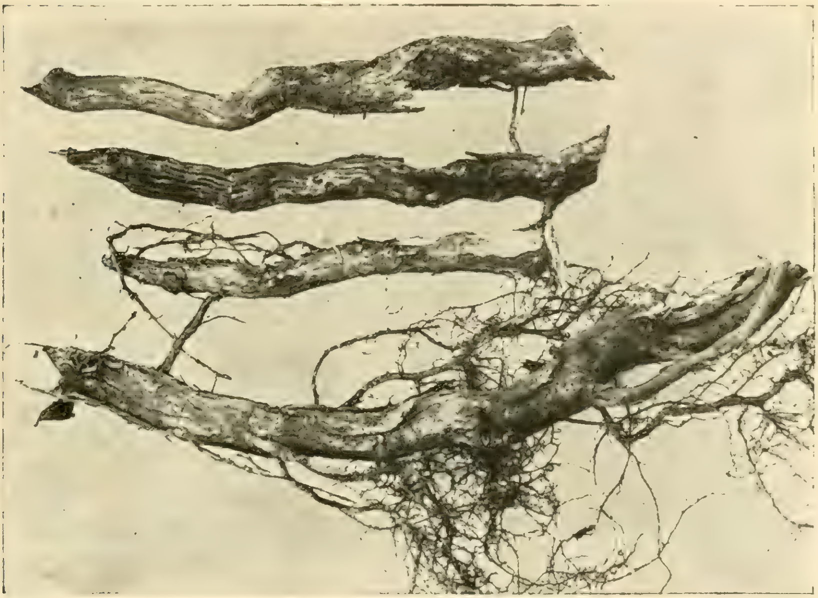


FIG. 363.—Portions of three grape roots denuded of their bark and fibrous roots by grape root-worms, and part of a similar root taken from a thrifty vine showing its normal bark and rootlets. Reduced in size. (After Slingerland.)

during the first two or three weeks. The eggs are laid in masses of 25 to 40 beneath the old bark or generally over the canes. The individual egg is one-twenty-fifth inch long, at first whitish, but soon turns yellow, and tapers at each end. The eggs hatch in from nine to twelve days, when the young larvæ drop to the ground and seek the roots. The young larvæ are only one-seventeenth inch long, so that they are able to penetrate the soil.

When established on the roots they feed freely and grow rapidly, becoming nearly full grown by fall. In the fall they descend several inches into the soil and make small earthen cells, in which they hibernate. In the spring they return to the roots nearer the surface, and those not already full grown feed until growth is completed. They then make small earthen cells 2 or 3 inches below the surface of the ground in which they transform to pupæ. These cells are easily broken open and the pupæ are thus crushed or killed by stirring the soil in cultivation. The pupa, shown in Fig. 364, *c*, is one-quarter to one-third inch long, whitish, with

FIG. 364.—The tender pupa of the grape root-worm in its earthen cell, enlarged natural size at *n*. (After Slingerland.)

the head, thorax and tip of the abdomen pinkish, and with spines on the head, appendages, and abdomen as illustrated. The pupæ are most abundant in New York during June, the pupal stage lasting about two weeks.

Control.—Extensive experiments made by several investigators have shown that the beetles may be very largely destroyed by thorough spraying with arsenate of lead just as they appear. By applying the poison when they are first noticed feeding they may be killed off before many of the eggs are laid, and sprayed vineyards have shown a reduction of over 90 per cent of the eggs found on untreated vines. Arsenate of lead should be applied at

the rate of 4 pounds to the barrel as soon as feeding marks are found on the foliage, and again a week or ten days later, and should be added to the Bordeaux mixture used for the diseases of the vine. The spraying must be done with the greatest thoroughness, as the beetles dislike the sprayed foliage and will seek out that which has been missed. The nozzles on traction outfits

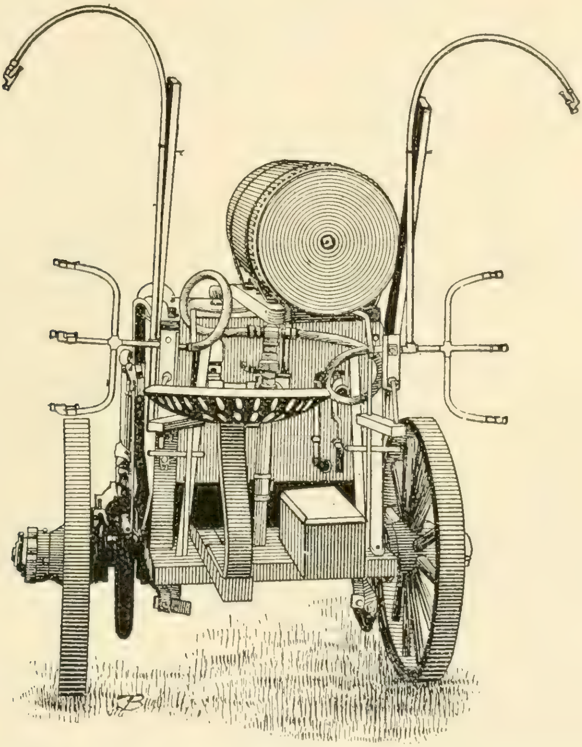


FIG. 365.—A geared horse-power vineyard sprayer. This is provided with a compressed air tank and an extra nozzle on each side directed downward in order to spray the tops of the vines. (After Quaintance and Shear, U. S. Dept. Agr.)

should therefore be arranged so as to hit all parts of the vines (see Figs. 365, 366) and the pump should maintain at least 100 pounds pressure. With the machines in common use not over 7 or 8 acres a day may be covered thoroughly, and about 125 gallons will be required per acre. If the work is hurried to cover greater

acreage, the treatment will usually be less effective. The beetle is noticeably less destructive in well-cultivated vineyards, and it has been shown that thorough cultivation in early summer breaks up the pupal cells and destroys large numbers of the pupæ. Most of the pupæ are within 2 or 3 inches of the surface and within $1\frac{1}{2}$ or 2 feet from the base of the vine. In the fall the earth should be thrown toward the vines to form a ridge along the row, so that the larvæ will mostly pupate near the surface of this ridge.

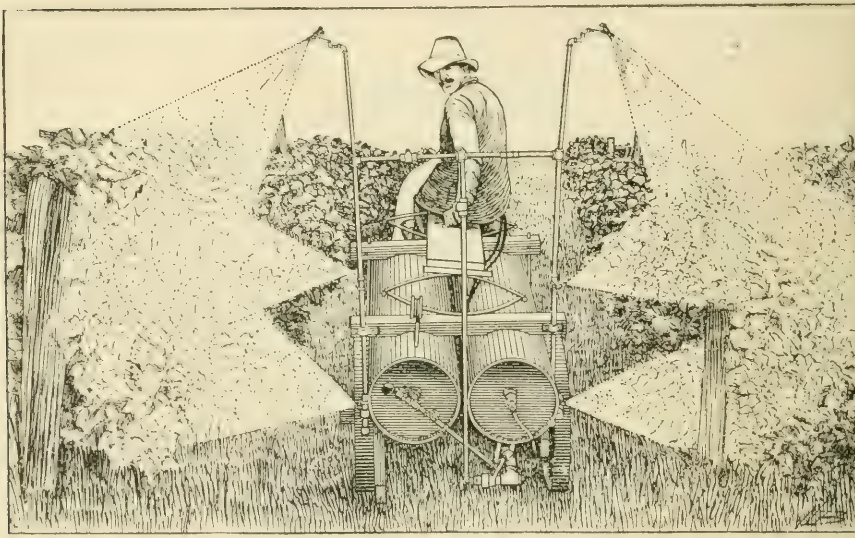


Fig. 366. —A compressed-air sprayer in operation, showing proper arrangement of nozzles for thoroughly spraying grapes. (After Quaintance and Shear, U. S. Dept. Agr.)

The next spring, when most of the larvæ have entered the pupal stage, this ridge should be thrown away from the vines, thus exposing the pupæ. A "horse-hoe" commonly used in vineyards is useful in this work, but a hand-hoe will need to be used to throw the earth away from the immediate base of the vine. The soil should then be kept well stirred by cultivation at frequent intervals, all of which is merely part of good practice, independent of the control of the root-worm.

The Grapecane Gall-maker *

The Grapecane Gall-maker is a small reddish-brown snout-beetle about one-eighth inch long, which lays its eggs in the canes,

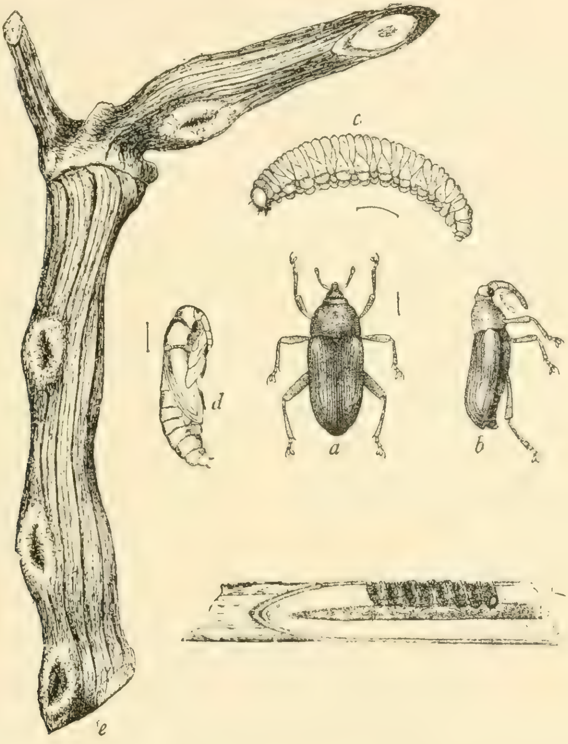


FIG. 367.—The grapecane gall-maker (*Ampeloglypter sesostris* Lec.): *a*, adult from above; *b*, same, side view; *c*, larva, side view; *d*, pupa; *e*, section of vine showing galls—all enlarged. (After F. M. Webster); *f*, section of cane showing newly made wound and egg in lower chamber—natural size. (After Brooks.)

giving rise to galls about twice the diameter of the cane and 1 or 1½ inches long, with a deep scar in one side. It has been noted

* *Ampeloglypter sesostris* Lec. Family *Curculionidæ*. See Fred E. Brooks, Bulletin 119, W. Va. Agr. Exp. Sta.; F. M. Webster, Bulletin 116, Ohio Agr. Exp. Sta.

as injurious in Ohio and West Virginia, and from the records seems to be generally distributed over the Eastern States, but is by no means a serious pest.

Life History.—The adult beetles appear in May and are gone by early July. They feed sparingly on the vine, making little pits in the tendrils, in the buds or bark of new canes or in the midribs on the under side of the leaves. The females soon lay their eggs and make the egg scars. These cause the galls and constitute practically the only injury to the vine. The eggs are laid just above a joint and beyond the outermost fruit, so that the injury does not interfere with the crop. A female eats out a small hole with her snout, in it lays a small yellowish-white egg, and fills up the hole with fibers scraped off from the surface of the cane. She then makes another hole immediately above this, but merely places a drop of liquid in it and then fills it up with fibers in the same manner. Eight to a dozen holes are thus made in a row and filled. Very soon this wound causes a swelling of the vine, but the gall does not reach full size for six or eight weeks. On vines producing dark-colored fruit, the wood about the wound takes on a purplish color. The galls seem to have but little effect on the growth and vigor of the vine, except that the canes are more readily broken by the wind or in pruning. The larva is a little yellowish-white, footless grub about two-fifths inch long, which feeds about the egg-chamber and then burrows in the pith. It becomes full grown in eight to ten weeks, when it pupates within the burrow; the beetle emerges in late August, and hibernates over winter.

As the scar in the side of the gall where the eggs were deposited remains open, a very large proportion of the larvæ are subsequently parasitized by various chalcis, and tachina-flies, which will probably prevent the insect ever becoming much of a pest.

Control.—The galls may be cut out and burned during July or August without any injury to the crop, as they occur beyond the fruit, and at that time will contain the larvæ or pupæ. As the beetles feed on the foliage and new growth it is probable that but little damage will result in vineyards well sprayed with arsenicals for other pests.

The Grapecane Girdler *

This beetle is very similar to the last except that it is black in color. Its native food-plant is the Virginia creeper, which it has deserted in West Virginia, and occasionally elsewhere, to attack grape. The species seems to occur generally through the Central and Eastern States.

Life History.—The life history is almost identical with that of the preceding species, the habit of the species differing only in the manner of oviposition. The eggs are laid in late May and

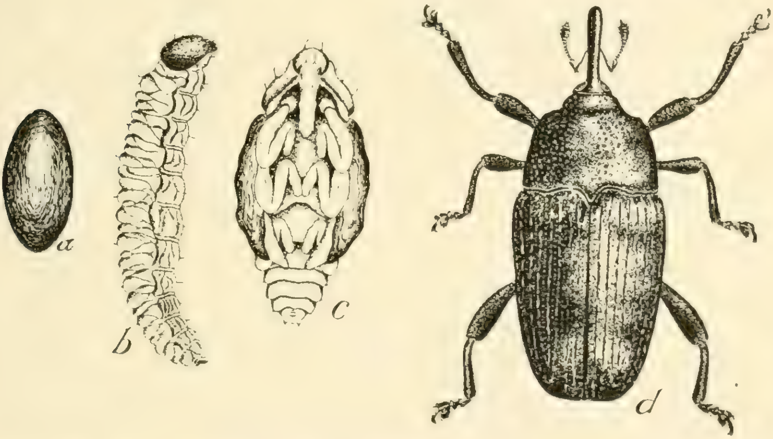


FIG. 368.—The grapecane girdler (*Ampeloglypter ater* Lec.): *a*, egg; *b*, larva; *c*, pupa; *d*, beetle—all enlarged. (After Brooks.)

early June. In laying the egg, the female deposits it in the same manner as does the previous species, and then instead of placing a series of holes in a row she makes them in a ring around the cane, only the first one containing an egg. She then goes to the next joint above and makes a series of holes around it, completely severing it, so that it hangs by a shred and soon drops. The little larva feeds in the pith of the joints on either side of the egg puncture, and these two joints die and drop to the ground. The larva becomes full grown in about a month and changes to a pupa in

* *Ampeloglypter ater* Lec. Family *Curculionidæ*. See Fred E. Brooks, Bulletin 119, W. Va. Agr. Exp. Sta.

FIG. 369.—Work of the grapecane girdler. (After Brooks.)

FIG. 370.—Work of the grapecane girdler. (After Brooks.)

its burrow soon after the dead section drops, first filling the burrow with little pellets of fibers. Two weeks later the adult beetle emerges, appearing during late summer. The whole life cycle thus requires sixty-five to seventy days. The beetles hibernate over winter.

Control.—The injured canes are quite conspicuous in early summer and by cutting them off a few inches below the egg scars the eggs and larvæ may be removed and destroyed. Brooks is of the opinion that the beetles will be largely destroyed in vineyards thoroughly sprayed with arsenicals for other grape insects.

The Grape Cane-borer *

During the spring young grape shoots sometimes suddenly break off or droop and die, and if examined a small hole will be found just above the base of the withered shoot, with a burrow leading from it into the main stem. In this burrow will be found a small brown beetle, a half inch long (Fig. 371, *a*), which is the cause of the injury. It has been sometimes called the apple twig-borer on account of the similar injury which it does to apple twigs, and it also attacks pear, peach, plum, forest and shade trees and ornamental shrubs, but it is particularly destructive to the grape. Its injury is most noticed in winter and early spring, and frequently results in killing all the new growth and sometimes the entire vine. Injury has been most severe in the States bordering the Mississippi from Iowa southward, where it is one of the most serious insect pests of the vine, and though the beetle occurs eastward to the coast it rarely does much damage farther east.

"It breeds in dying wood, such as large prunings, diseased canes, and also in dying or drying wood of most shade and fruit trees. It has also been found by the writer [Marlatt] breeding very abundantly in roots of uprooted maples and in diseased tamarisk stems. In old, dry wood it will not breed, so far as known, nor in vigorous live growth, but seems to need the dying

* *Amphicerus bicaudatus* Say. Family *Ptinidæ*. See C. L. Marlatt, Farmers' Bulletin 70, U. S. Dept. Agr.

and partially drying conditions mentioned. The insect has but one brood yearly. The beetles mature for the most part in the fall, and generally remain in their larval burrows until the following spring. A few may leave the burrows in the fall and con-

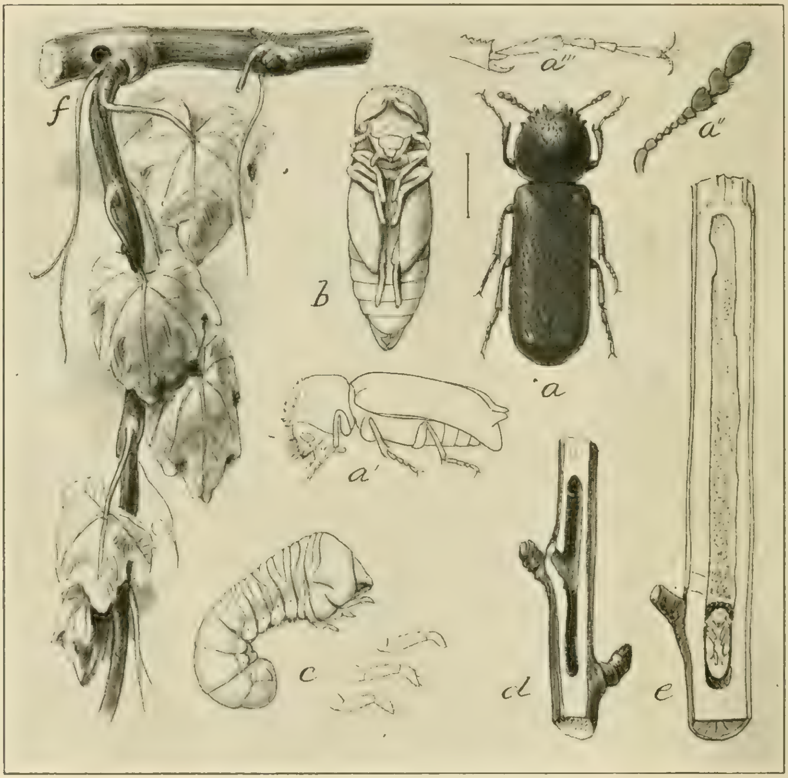


FIG. 371.—The grape cane-borer (*Amphicerus bicaudatus* Say): *a*, beetle, back and side views; *b*, pupa; *c*, larva, with feet enlarged; *d*, burrow in apple twig made by adult; *e*, larval gallery in tamarisk, with pupa in cell at end; *f*, injury to young shoot and cane showing entrance of beetle near *f*, and the characteristic wilting and new growth—all much enlarged except *d*, *e*, *f*. (After Marlatt, U. S. Dept. Agr.)

struct others in the twigs of apple or other plants in which to hibernate. In the spring, however, they begin their destructive work early, burrowing into the axils of the grape and occasionally

also into other plants. This is undoubtedly partly for food, but seems largely malicious, for it certainly has nothing to do with egg-laying. . . . The eggs are laid chiefly in May or April in its southern range, and the larvæ develop during summer, transforming to beetles and pupæ in the fall. On the Pacific coast a closely allied, but somewhat larger species (*Amphicerus punctipennis* Lec.) . . . probably has similar . . . habits . . ."

Control.—All diseased wood and prunings should be removed in late spring, thus destroying the material in which the larvæ develop. If this is neglected and the beetles appear in the vineyard, the only means of stopping their depredations is to cut out by hand the affected parts and destroy the beetles. On warm days the beetles may sometimes be collected while running over the vines.

The Grapevine Flea-beetle *

When the grape buds are swollen in the spring they are often attacked by numbers of little blue or greenish beetles which eat out or entirely consume them. When abundant these little beetles may destroy all the buds on a vine, thus greatly retarding the leafing out or even occasionally killing the plant. The beetle is about one-fifth inch long, of robust shape, and possesses the thick thighs characteristic of flea-beetles, which enable it to jump a considerable distance when disturbed. It is common throughout the States east of the 100th meridian and nearly related species do similar damage on the Pacific Coast. (See Quayle, l.c.) The wild grape is undoubtedly the natural food-plant of the species, though it is occasionally found on plum, apple, pear, quince, blue beech and elm.

Life History.—After feeding a few days the female beetles commence to lay their eggs in cracks of the bark at the base of the buds, or in any crevice or in the cavity eaten out of the bud by the beetle, or sometimes on the foliage. The eggs are a long

* *Haltica chalybea* Ill. Family *Chrysomelidæ*. See Quaintance, l.c.; Hartzell, l.c.; and M. V. Slingerland, Bulletin 157, Cornell Univ. Agr. Exp. Sta.

oval shape, one-fortieth inch long, and of a dark straw-yellow color. The eggs hatch just as the young leaves are expanding; and upon them the young larvæ feed greedily. The larvæ feed on the upper surface of the leaf, eating out irregular holes through the skin and into the soft tissue, and become full grown in three or four weeks. The young larvæ are a very dark brown, but when grown they are one-third inch long and a dark yellowish-brown, marked by regular rows of blackish tubercles each of

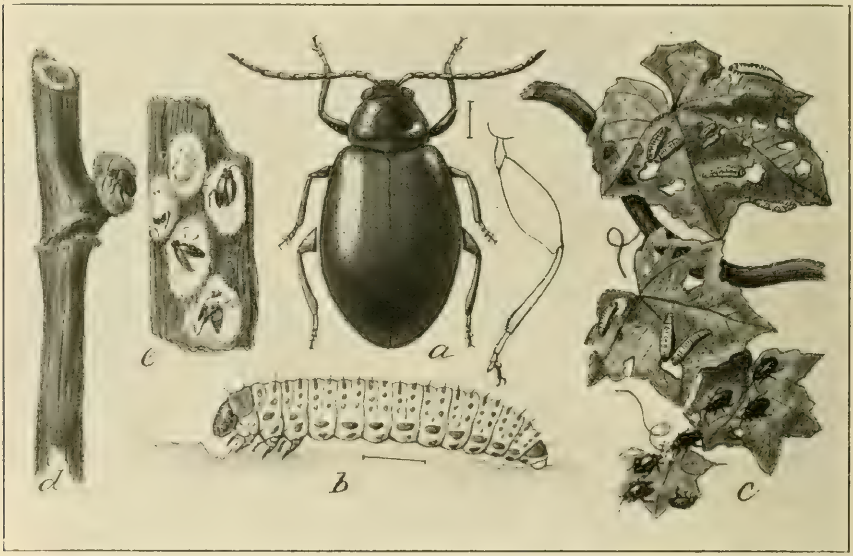


FIG. 372.—The grapevine flea-beetle (*Haltica chalybea* Ill.): *a*, adult with hind leg at right further enlarged; *b*, larva, much enlarged; *c*, beetles and larvæ on foliage—natural size; *d*, beetle feeding on bud; *e*, diseased beetles. (After Marlatt, U. S. Dept. Agr.)

which bears a small hair. The head, anal and prothoracic plates and legs are black. The full-grown larva drops to the ground and an inch or two beneath the surface makes a small cell in which it transforms to a white pupa, from which the adult beetle emerges in one or two weeks. In New York there is but a single generation, but more than one generation may occur in the South. Upon emerging the beetles feed on the grape and

other plants, doing no particular damage, and enter hibernation in the fall.

Control.—Where vineyards are regularly sprayed with arsenicals there will be but little trouble with the flea-beetles, as the grubs are very easily destroyed on the foliage. In neglected vineyards the beetles often become very abundant and may be quite destructive in such localities. Where it is necessary to combat the beetles to prevent injury to the buds, close watch should be kept for them and the buds should be thoroughly

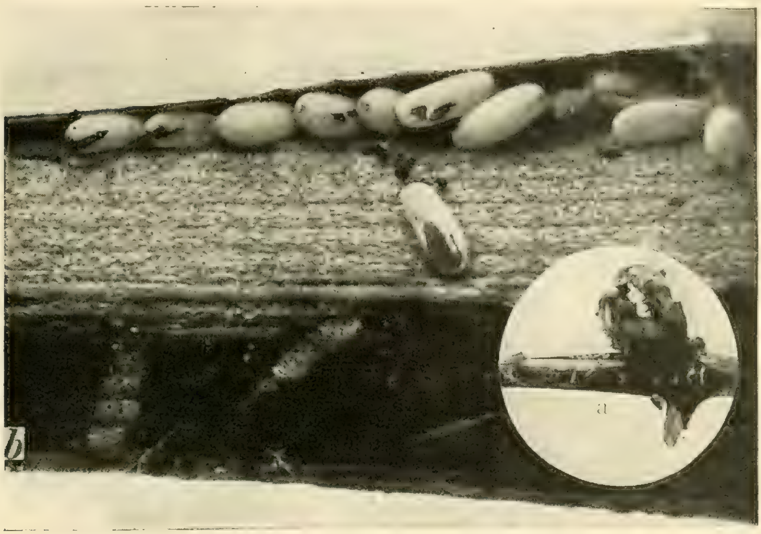


FIG. 373.—Eggs of the grapevine flea-beetle, natural size at *a*, and enlarged at *b*. (After Slingerland.)

sprayed at once, using 8 pounds of arsenate of lead per barrel. Usually this will need to be applied just as the buds are becoming well swollen, and must be applied promptly and thoroughly, as the beetles work quickly and a day's delay may mean the destruction of the buds. In a small vineyard or on a few vines the beetles may be collected by hand in the early morning when they are sluggish, or may be jarred to canvas-covered frames kept saturated with kerosene placed beneath the vines.

The Rose-chafer *

About the time the grape is in bloom, immense swarms of the common Rose-chafers or Rose-bugs often appear, covering the plants, feeding on the blossoms, later attacking the young fruit and foliage, and sometimes eating the leaves quite bare except the larger veins. The chief damage, however, is done by destroying the blossoms or newly set fruit, or by so injuring the young

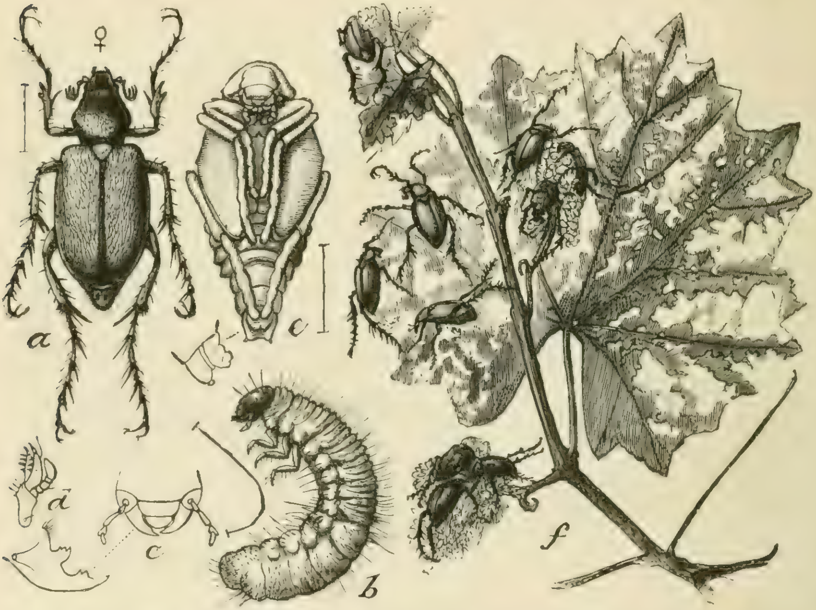


FIG. 374.—The rose chafer (*Macrodactylus subspinosus* Fab.): *a*, beetle; *b*, larva; *c*, *d*, mouth-parts of same; *e*, pupa—all much enlarged; *f*, beetles at work on foliage—natural size. (After Marlatt, U. S. Dept. Agr.)

berries that they are misshapen and worthless. The beetle is about one-third inch long, of a light-brownish color, covered with numerous lighter hairs, and has very long spiny legs, which always seem to be in its way and make it most awkward and clumsy. It is a very general feeder, being common on roses,

* *Macrodactylus subspinosus* Fab. Family *Scarabæidæ*. See Quaintance, l.c.; Hartzell, l.c.; J. B. Smith, Bulletin 82, N. J. Agr. Exp. Sta.; and Fred Johnson, Bulletin 97, Part III, Bureau of Entomology, U. S. Dept. Agr.

from which the common name is received, and also on such ornamentals as *Spiraea* and *Deutzia*, while it frequently injures the blossoms of apple, plums, cherries and peaches, and when very abundant will attack various vegetables, grasses, and grains. The species occurs commonly from Canada to Virginia and Tennessee and westward to Colorado, and in Texas and Oklahoma, but seems to do but little damage west of the Mississippi, being most injurious in the Middle States. It is particularly destructive where there are areas of light sandy soil grown up in grasses and weeds, upon the roots of which the larvæ feed.

Life History.—After feeding three or four weeks the beetles suddenly disappear. During the middle of June, in New Jersey, the females lay from 12 to 20 eggs, depositing them in the soil singly. These hatch in two to three weeks and the larvæ feed on the roots of various grasses and possibly weeds and other vegetation. They become nearly full grown by fall, when they go below the frost line and hibernate over winter. The larva looks very much like a small white grub, which it closely resembles in every way, and is about three-quarters inch long when full grown (Fig. 374, *b*). In the spring the grubs come near the surface of the soil and enter the pupa stage, which lasts from ten to thirty days according to the temperature. There is but one generation a year, and the injury is done by the beetles during the three or four weeks they are abroad.

Control.—When the beetles are very abundant the only satisfactory method of control is to pick them by hand or jar them from the vines onto frames from which they may be collected. In jarring, an umbrella-shaped frame covered with canvas or, preferably, oilcloth, which slopes to a can of kerosene at the bottom, is often used, being somewhat similar to that used for the plum curculio. This is held under the vines and they are sharply jarred or shaken, when the beetles will drop to the frame, particularly in early morning. Handpicking into a can of kerosene and water is probably the most common method, however. Where the beetles are not excessively abundant they have been controlled in some cases by thorough spraying with arsenate

of lead, 5 to 10 pounds per barrel, preferably applied with Bordeaux mixture, and recent experiments of the N. Y. Agricultural Experiment Station with 5 pounds of arsenate of lead and 12 pounds of glucose per barrel gave excellent results. The numbers of the pest may also be much reduced by keeping down the grass and weeds in the vineyard, and particularly on light sandy soils adjoining lands should be broken up and cultivated in annual crops as far as possible, thus reducing the breeding grounds of the pest. By bagging the grapes as soon as the fruit is set the clusters may be protected from this as well as other pests and diseases wherever such treatment is practicable.

The Grape Leaf-hopper *

Wherever the grape is grown in the United States and Canada, the foliage will be found more or less infested with the small Leaf-hoppers, often locally called "thrips," which feed and breed on the under surface of the leaves during the season. By late summer the vines may be covered with the hoppers, which will fly off in clouds when disturbed, and every year there is serious injury in various localities. The injury is done by the little hoppers sucking out the juices of the leaves through their tube-like mouth-parts. A small white spot first appears around the feeding puncture, due to the loss of chlorophyll in the leaf, and when the punctures have become numerous the leaf has a variegated appearance. As the injury increases the leaf yellows and finally dries up and falls to the ground. Where it becomes general, this injury reduces both the quantity and quality of the fruit. The pest is an insidious one, as it is not usually noticed until it becomes very abundant in late summer, by which time most of the injury has been done and it is too late to prevent it. For this reason its control has been very generally neglected by grape growers with a consequent loss the cause of which is often unsuspected.

* *Typhlocyba comes* Say. Family *Jassidæ*. See Quaintance, l.c.; Hartzell, l.c.; Quayle, l.c.; and M. V. Slingerland, Bulletin 215, Cornell Univ. Agr. Exp. Sta.

The adult hoppers are about one-eighth inch long and the wings are prettily marked with yellow and red as shown in Fig. 375. "In summer the young and adult insects are light yellowish in color, but before going into hibernation, the eyes of the adults darken and the peculiar yellow spots on the wings change to an orange red, thus giving the hibernating adults a general reddish appearance. These darker markings on the adults vary so much that nine different varieties are now recognized, two of which are represented at *b* and *c*, in Fig. 375. Often several of the varieties

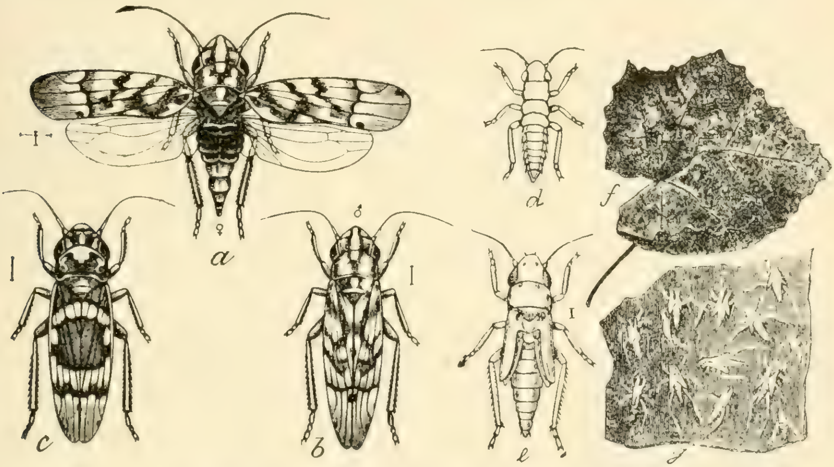


FIG. 375.—Grape leaf-hopper (*Typhlocyba comes*): *a*, adult female; *b*, adult male; *c*, another form of the species, showing variation in markings; *d*, newly-hatched nymph; *e*, last stage nymph; *f*, appearance of injured leaf; *g*, cast pupa skins—*a*, *e*, much enlarged; *g*, less enlarged; *f*, reduced. (From Marlatt, U. S. Dept. Agr.)

may be found together on the same vines, but usually one color form largely predominates." The nymphs are a light yellowish-green color with lemon-yellow stripes on each side of the body. They pass through five molts before becoming adults, the wing-pads gradually getting larger in the later stages. No very similar insects are common on the grape, so that the pest is readily recognized.

Life History.—The adult hoppers hibernate over winter under leaves, grass, or trash in or near the vineyard, in neighboring

woods, along ditches or fences, etc. They emerge about May 1 in New York and at first feed on whatever succulent foliage may be available. By the time the grape foliage appears they have mostly emerged and infest the vineyards. These hibernating hoppers feed and breed on the lower leaves, disappearing about the time the first young become adult. After a few weeks the females commence egg-laying, which continues for about two months. The eggs are laid just beneath the surface of the leaf in groups of from six to nine, or singly, and as they are but one-thirty-fifth inch long and almost transparent, they are scarcely visible save for the eyes of the embryonic nymphs. The eggs hatch in nine to fourteen days. The young nymphs feed like the adults, at first on the lower leaves, but soon spread to all parts of the plant. In New York they become grown in thirty to thirty-five days, and there is but one full generation a year, with a partial second generation, most of the individuals of which probably do not mature before frost. Feeding continues until cool weather, when the adults enter hibernation. In Colorado, New Mexico and California and probably throughout the South, there are two full generations a year. In California, according to Quayle, the nymphs from eggs laid by the hibernating hoppers appear by the middle of May and the following generation of nymphs about the middle of July.

Control.—Cleaning up all fallen leaves and trash in the vineyard during the winter, or plowing it under in the early spring, will reduce the number of hibernating hoppers, and it has been observed that they are much less numerous in vineyards where clean culture is practiced. The burning over of adjacent meadows, wood lots and fence rows will also be advisable where practicable.

In California, where the vines are not trellised, a hopper-cage, which has been fully described by Quayle, l.c., is successfully used for catching the hoppers before they commence to oviposit in the spring. In the East this could not be used, and Professor Slingerland has shown that the hibernated hoppers may be caught on sticky shields before they oviposit. "A light wooden frame is made 7 or 8 feet long by 4 feet high. To the crosspiece at the

bottom, which should be up from the ground about a foot, are fastened several stiff wires of the shape of a hayrake tooth. These are fastened so that the points curve inward and downward to the ground at the base of the plants when the shield is held in place beside the vines. The whole framework, including the wires, is covered with oilcloth, which is coated with a sticky substance, made by using melted resin, 1 quart, and castor oil, 1 pint." Tanglefoot might be used instead. The hoppers are on the lower leaves early in the season, so that the frames need not be high, and it is at that season that it is important to catch them. The vines will need to be gone over frequently, a man carrying a shield on either side and jarring the vines so that the hoppers will fly off and be caught on the shields. The young hoppers may be killed by spraying with whale-oil soap, 1 pound to 10 gallons, 10 per cent kerosene emulsion, or tobacco extract. In California a resin spray composed of 1 pound of resin and one-quarter pound of lye dissolved in 15 gallons of water is used. This work must be done with the greatest thoroughness, as the hoppers must be hit to be killed. Underspray nozzles must be used and handled by men who will cover the under surface of all the leaves. This cannot be done by fixed nozzles, unless very high pressure and many nozzles are used. The work is necessarily slow and expensive and should be commenced as soon as the young appear, when they may be more easily destroyed and when there is less foliage to be sprayed. Several applications will usually be necessary.

The Grape Leaf-folder *

Very frequently grape leaves are found folded or rolled together, with the interior surface more or less skeletonized, from which a slender larva will wriggle out and fall or hang suspended on a silken thread. The Grape Leaf-folder occurs throughout the United States, and though usually not injurious, sometimes becomes abundant enough to do serious damage.

* *Desmia funeralis* Hübner. Family *Pyralidæ*. See Quaintance, and Quayle, l.c.

The moth is black with white spots on the wings, and bands across the abdomen, as shown in Fig. 376. The larva is about an inch long, of a greenish-white color, with head and prothoracic shield light brown, and with brown spots on the sides of the first two thoracic segments.

Life History.—"There are two broods each year in the more Northern States and three or possibly more in the South. The insect winters in the pupal stage in the folded and fallen leaves, the moths appearing in the spring shortly after the foliage puts

FIG. 376.—The grape leaf-folder (*Desmia funeralis* Hübn.): *a*, male moth and enlarged antenna of same; *b*, female moth; *c*, larva; *d*, head and thoracic segments of same enlarged; *e*, pupa; *f*, tip of pupa—enlarged; *g*, grape leaf folded by larva. (After Marlatt, U. S. Dept. Agr.)

out, and the eggs are placed in small patches here and there on the vine. Upon hatching, the young larvæ attack the foliage, folding the leaves as stated. Mr. Johnson has observed that the larvæ of the first brood may attack bunches of grape blossoms and young fruit in a way similar to the grape-berry moth. In three or four weeks the larvæ are full grown and transform to pupæ within the folded leaves, moths emerging eight or ten days later. By midsummer and fall the insects become quite abundant, and in badly infested vineyards the folded leaves are everywhere in evidence and are quite con-

spicuous from the color of the lower surface. In the fall the larvæ pupate in the folded leaves and pass the winter in these on the ground."—Quaintance.

Control.—Where but a few larvæ occur they may be crushed by hand, and if this is done with the first brood it will greatly reduce the numbers later in the season. Vineyards sprayed with arsenicals will be protected, as the young larvæ will be killed before they fold the leaves. By collecting and burning the fallen leaves or plowing them under deeply, many of the hibernating pupæ may be destroyed.

Hawk-moth Larvæ *

Several species of Hawk-moth or Sphinx-moth larvæ are commonly found on the vine. Most of them are widely distributed throughout the country and feed on wild grape and Virginia creeper. Usually they are not numerous enough to do serious damage, and as they strip a branch at a time, they are readily seen and may be destroyed before much injury is done. Occasionally, however, one or two larvæ may entirely strip a young vine, and exceptionally the larvæ appear in considerable numbers on old vines, stripping them bare of foliage. They are large, smooth-bodied larvæ, 2 to 4 inches long, and may be distinguished from those of other families of moths by the strong horn on the next to the last segment, which has given them the common name of horn-worms. In many species, this horn is present only in the first one or two stages of the larva, disappearing with the next molt and being replaced by a bright eye-spot, as shown in Fig. 377, *c*, *d*. The life history of the various species is much the same, except that some have only one, while others have two generations a year in the North, though most all probably have two generations in the South. They hibernate as large dark-brown pupæ, 3 or 4 inches below the surface of the ground, and the moths emerge in spring. The moths are particularly attracted to petunias, and may often be caught hovering over them at

* Family *Sphingidæ*. See O. Lugger, 4th Report State Ent. Minn.; Ida M. Eliot and Caroline M. Soule, "Caterpillars and their Moths." (N. Y., 1902).

night. The eggs are laid on the foliage, usually singly, and the larvæ hatch in a few days. They eat ravenously, and will consume an enormous number of leaves within a few days. Usually the

FIG. 377.—The achemon sphinx (*Pholus achemon* Dru.): *a*, moth; *b*, egg; *c*, young larva; *d*, mature larva; *e*, pupa; *f*, parasitized larva—all natural size. (After Marlatt, U. S. Dept. Agr.)

coloration of the larvæ changes more or less as they grow, so that when full grown they are different from the younger stages. When there are two generations, the second generation of larvæ

will appear in late July, but whether one or two generations occur, the larvæ maturing in late summer transform to pupæ which hibernate.

Control.—Usually the work of the larvæ is so conspicuous and they are so easily found that they may be controlled by hand-picking. Where the vineyards are sprayed regularly for other pests there will be but little trouble with these larvæ, as they will be killed while young.

THE ACHEMON SPHINX.* This is one of the most common species on the grape. The young larva is a light-green color with a long reddish-brown horn which becomes shorter as the larva grows and finally disappears and is replaced by a large polished eye-spot. The mature larva is about $3\frac{1}{2}$ inches long, and varies in color from straw-color to reddish-brown. Along the sides are six diagonal cream-colored spots, on the second to seventh abdominal segments inclusive. The body is much wrinkled and dotted with small spots, dark on the back and lighter on the sides. The head and first two thoracic segments are small and are retracted into the metathorax when at rest. Just before pupation the larva becomes a pink or crimson color. The moth has a wing expanse of 3 inches and is brownish-gray, variegated with light brown, and deep brown spots; the hind wings are pink, with a dark shade across the middle, still darker spots below this, and a broad gray band behind. The body is reddish-gray with triangular brown patches at the base of the wings, which are edged with white.

THE PANDORUS SPHINX.† This nearly related species is also common on the vine, but rarely does much damage. The wings expand 4 to $4\frac{1}{2}$ inches, and are a light, olive color, mixed with gray, marked with patches of darker olive green, and with portions of a rosy hue, especially on the hind-wings. The body is light greenish-brown marked with dark olive patches. The larva is very similar to that of the last species, but has only five rather oval cream-colored spots on the sides of the third to seventh abdominal segments.

* *Pholus achemon* Dru. † *Pholus pandorus* Hbn.

THE GRAPE-VINE HOG CATERPILLAR.* This is one of the most common sphinx larvæ on grape and Virginia creeper. The grown larva is 2 inches long, of a green color, covered with small yellow dots or granulations. Along the sides of the body are seven oblique yellowish stripes margined behind with a darker green. A white stripe with a deep green margin extends from behind the head to the horn, on either side of the back, and along the middle are a series of seven spots, varying in color from red to pale lilac and each set in a patch of pale yellow. Frequently, especially in the second generation, specimens are found which are

FIG. 378. The grapevine hog-caterpillar moth (*Ampelophaga myron* Cram).—natural size. (After Lugger).

a light pinkish instead of green and are marked with darker shades of red and brown so that they may easily be mistaken for another species. The wings of the moth expand 2½ inches and are long and narrow. The fore-wings are olive green, crossed by bands of greenish-gray, while the hind-wings are dull red shading to greenish-gray next to the body. The body is pale green, with the head and shoulders deep olive green.

THE WHITE-LINED SPHINX.† This species has a long list of food-plants, the larvæ feeding and multiplying on purslane, chickweed and other weeds, and then attacking various crops, among which is the grape. (See p. 247). They are about 3½

* *Ampelophaga myron* Cram. † *Deilephila lineata* Fab.

inches long and quite variable in color, some being yellowish-green with black eye-spots along each side of the back and with faint blackish stripes, while others are black with yellowish spots, as shown in Fig. 379. The moth is shown natural size. The fore-wings are an olive color with a pale buff stripe across the middle,

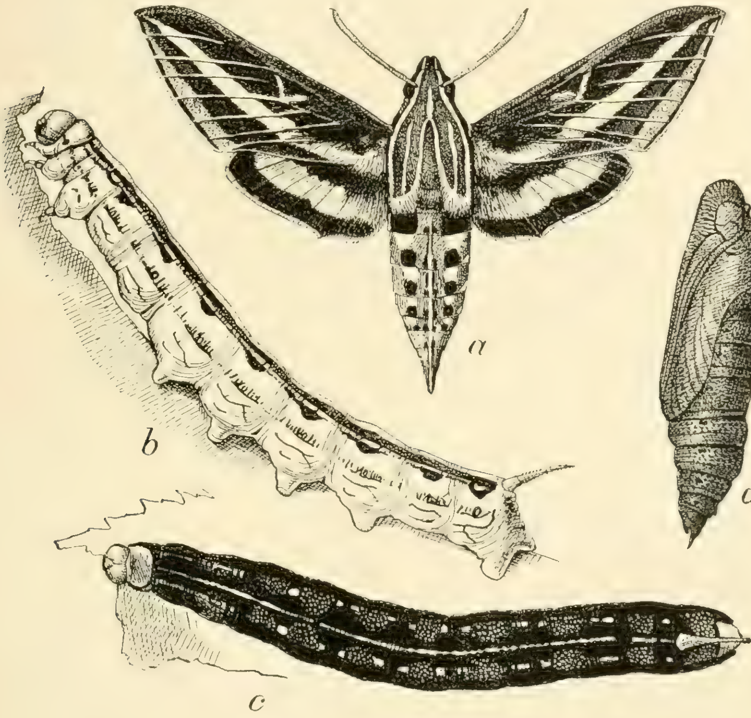


Fig. 379.—The white-lined sphinx (*Deilephila lineata* Fab.): *a*, moth; *b*, pale larva; *c*, dark form of larva; *d*, pupa—all natural size. (After Chittenden, U. S. Dept. Agr.)

and are margined with gray, and the hind-wings are crossed by a wide rosy band, the remainder being almost black, except the white margin. The thorax is marked with several white lines as illustrated, and the abdomen is greenish olive spotted with white and black.

Abbot's Sphinx.* This caterpillar is $2\frac{1}{2}$ inches long, varying in color from dull yellow to reddish brown. Each segment is marked by six or seven transverse black lines, and longitudinally with dark-brown streaks. On the next to the last segment is a polished black tubercle, or eye-spot, ringed with yellow. The moth is a dull chocolate-brown color, with a wing expanse of $2\frac{1}{2}$ inches. The fore-wings are pale beyond the middle and are streaked with darker brown as illustrated. The hind-wings are yellow with a brown border. The terminal segments of

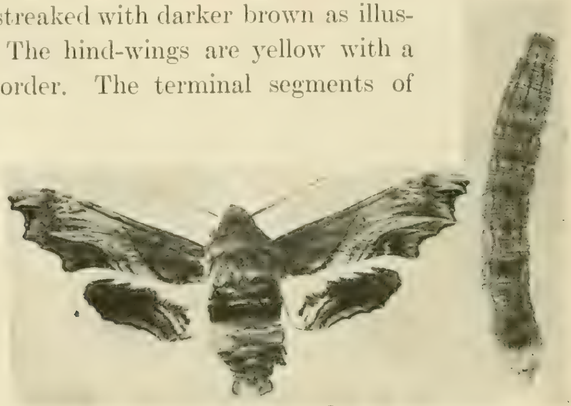


Fig. 380.—Abbott's sphinx (*Sphecodina abbottii* Swain) and its larva—natural size. (After Lugger.)

the abdomen bear tufts of scales on either side, making the abdomen appear truncated instead of pointed, as in most sphinx moths.

The Grape-berry Moth †

The larvæ of the Grape-berry Moth are the most common cause of wormy grapes. The first generation of larvæ web together the grape clusters before the blossoms open or soon after the grapes are set, and feed upon the clusters. Later the larvæ bore into the green and ripening fruit, producing purplish spots resembling the appearance of injury by the black rot. The berries decay from the work of the larvæ and from the entrance

* *Sphecodina abbottii* Swain.

† *Polychrosis viteana* Clem. Family *Tortricidæ*. See Quaintance, l.c.; Hartzell, l.c.; M. V. Slingerland, Bulletin 223, Cornell Univ. Agr. Exp. Sta.; and Gossard and Houser, Circular 63, Ohio Agr. Exp. Sta.

of fungous diseases. The insect occurs throughout the United States, but has been particularly injurious in the Chatauqua, N. Y.,

FIG. 381.—American grape-berry moth, enlarged. (After Slingerland.)

Erie, Pa., and Northern Ohio grape belts. So far as known the grape is the only food-plant and the species is a native one, though its habits are very similar to a nearly related European species.

The adult is a little purplish-brown moth, with wings expanding not quite one-half inch, and shaded with brownish markings

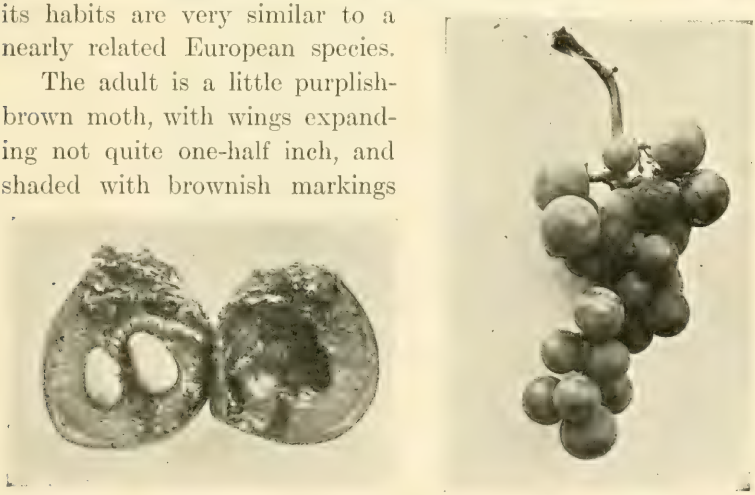


FIG. 382.—The work of the grape-berry moth; infested cluster and single berry opened to show larva at work—enlarged. (After Slingerland.)

as shown in Fig. 381. The ground color is lilaceous or leaden-blue and the spots are dark brown.

Life History.—The moths appear in the spring as the shoots of the grape are pushing out, and continue to emerge for some weeks. The earlier ones lay their eggs on the blossom clusters, while the later ones deposit them on the young grapes. The minute flat, scale-like eggs are stuck to the surface of the stems or berries, and look like small glistening, whitish spots. The little larvæ hatching from them feed on the blossoms and small

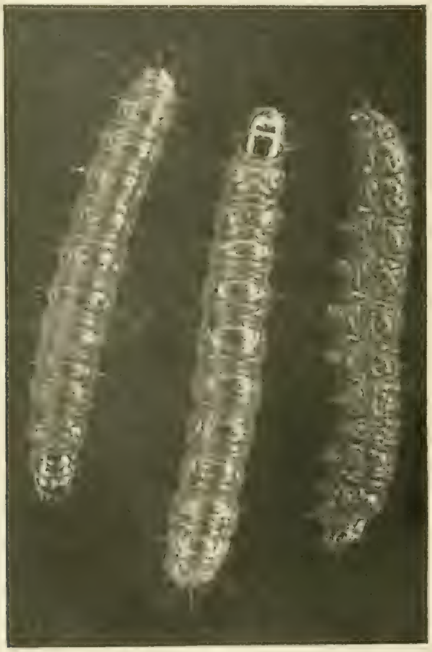


FIG. 383.—Grape-berry moth caterpillars, enlarged. (After Slingerland.)

berries, webbing the clusters together, and might do much more damage than the later generations were it not that they are much fewer in number, there being a great mortality of the insects over winter. The larvæ become full grown in about three weeks. The mature larva is about three-eighths inch long, varying in color from dark greenish to dark purplish, with a light-brown head and black thoracic shield. The body is covered with numerous faintly outlined darker spots, from which arise whitish

hairs, as shown in Fig. 383. The larva cuts out a piece of a leaf on three sides, folds it over and fastens the free edge to the leaf with silk. The fold is then lined with a thin layer of silk, making a thin cocoon in which it transforms to a light greenish-brown pupa, from which the moth emerges twelve to fourteen days later. The moths of the second and later generations place their eggs on the berries and the larvæ bore into them and feed on the pulp and seeds. In New York the moths of the second generation appear in early July and the second generation of larvæ occurs

Fig. 384.—Grape leaf showing cocoons in the making and finished by grape-berry moth caterpillars—natural size. (After Slingerland.)

during July and August. In New York those larvæ of the second generation which mature before mid-August pupate and give rise to a third generation, while those maturing later transform to pupæ, but hibernate. Often there is nearly a complete third brood in that latitude, and further south there are undoubtedly at least three generations. The winter is passed in the pupal stage in the cocoons, which break off from the fallen leaves.

Control.—Infested berries should be picked off both to destroy the larvæ and to prevent the spreading of fungous diseases. Plow-

ing under the fallen leaves either in fall or early spring should result in burying many of the pupæ so as to prevent the escape of the moths, and is good practice for other grape pests. The principal reliance should be placed upon spraying with arsenate of lead, 3 pounds per barrel, or one-half pound of Paris green, applied with Bordeaux mixture, to which a soap "sticker" should be added (see p. 46) to make the mixture more adhesive to the berries. The first spraying should be made before the blossoms open, to catch the early larvæ; the second should be made as the grapes finish blooming; and the third, early in July. The addition of the "sticker" is most important in the last spraying, when the berries are partly grown. The spray must be applied with sufficient number of nozzles and pressure to penetrate the foliage and cover the clusters thoroughly. In a small home vineyard the clusters might be protected by bagging them as soon as the fruit is set.

The Grape Curculio *

The larvæ of the Grape Curculio feed on the pulp and seeds of the berries, causing wormy grapes, much as do those of the berry-moth. The larvæ may be readily distinguished, for those of the curculio are white, footless grubs, while those of the berry-moth are greenish, with well-developed legs, and are quite agile, wriggling away quickly when disturbed. The adult curculio is a small, brown, robust, snout-beetle about one-tenth inch long, and nearly as broad. It is very difficult to see, looking like a bit of dirt or the excreta of some of the larger caterpillars common on the vine. It is common from Arkansas to Minnesota eastward to New York and North Carolina. It has been particularly injurious in West Virginia, and seems to be most harmful in that latitude.

Life History.—The beetles hibernate over winter in or near the vineyards, especially along the edge of woodlands. They

* *Craponius inæqualis* Say. Family *Curculionidæ.* See Quaintance, l.c., and Fred E. Brooks, Bulletin 100, W. Va. Agr. Exp. Sta.

appear in the spring about the time the grapes blossom and feed upon the foliage for three or four weeks until the berries are about

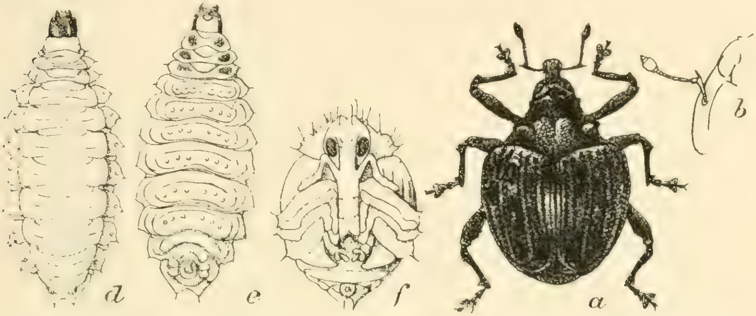


FIG. 385.—The grape curculio (*Craponius inæqualis* Say): *a*, beetle; *b*, head of same from side; *d*, larva from above; *e*, same from below; *f*, pupa—all much enlarged. (After Quaintance, U. S. Dept. Agr.)

one-fourth grown. The beetles cut small characteristic holes in the leaves, and this habit of feeding on the foliage so long makes it possible to kill them with arsenicals before oviposition is com-

FIG. 386.—The grape curculio in act of egg-laying—natural size; *e*, showing position of egg in grape—enlarged. (After Brooks.)

FIG. 387.—Grape curculio larvæ—natural size. (After Brooks.)

menced. In West Virginia the females begin egg-laying late in June, most of the eggs being laid in early July, but egg

laying may continue for eighty-one days, during which time a female will lay an average of 257 eggs. The female excavates a small cavity in the berry in which the egg is placed and hatches in four to six days. Infested berries often show a purplish spot around the egg-puncture. The larva bores in the pulp and in

FIG. 388.—Grapes showing egg-punctures of grape curculios. (After Brooks.)

three or four days reaches the seed, which is then devoured. The larva becomes full grown in twelve to fifteen days, when it eats its way out of the berry and drops to the ground in search of a suitable place to pupate. The mature larva is white, about one-third inch long, tapering from the middle of the body toward either end, without legs, and clothed with fine short hairs. The

FIG. 389.—Showing the resemblance of the grape curculios at 2 to excrement of sphinx caterpillars at 1, and mummied grapes at 3. (After Brooks.)

larvæ make small earthen cells under stones, lumps of earth or just below the surface of the soil, and in them transform to pupæ, from which the beetles emerge in eighteen to nineteen days. Thus the complete life cycle from egg to adult requires thirty-five days. The hibernating beetles are still abroad when the new

beetles appear, and Brooks states that the average life of a beetle is one year and nineteen days. Although the beetles of the new brood lay some eggs, but few of them develop, and in West Virginia there is practically but one generation, although farther south a second generation may occur. The beetles feed until fall, when they enter hibernation.

Control.—As the beetles feed so long on the foliage in early summer they may be readily killed by spraying with arsenicals as advised for the berry-moth and grape root-worm beetle. Thorough cultivation in midsummer would doubtless destroy some of the pupæ in the same manner as in the case of the root-worm. Infested fruit may be collected and destroyed as for the berry-moth with equally good results. Where spraying is regularly practiced there probably will be little need of resort to other methods.

CHAPTER XXVI

SOME INSECTS INJURIOUS TO ORCHARD FRUITS

The San José Scale *

PROBABLY the most serious of all the insect pests of the orchard is the San José Scale, for it will kill young trees in two or three years, and old trees must be sprayed annually to keep it under control. So insidious is the attack of the pest to those unfamiliar with it that it has killed many thousands of trees before the owners suspected its presence. It may be most readily detected on the fruit, which becomes spotted with small red circles which form around the scales, but usually the fruit is not attacked until the tree is badly infested. On the young twigs and along the veins of the leaves a similar reddish discoloration appears around the scales. The trunk and branches covered with scales have a rough grayish appearance, as if they had been coated with dark ashes. By scraping the surface the soft, juicy, yellowish insects will be revealed beneath the covering scales. If a single female insect be examined it will be found that it is covered by a small, circular scale, varying from grayish to blackish in color, formed of concentric circles, the centre of which is quite convex and forms a "nipple," which is yellowish and shining when the surface is rubbed off. If this scale be raised with a pin, beneath it may be seen a small, soft, oval, orange-colored, object, which is the true female insect. She is an almost shapeless mass of protoplasm, lacking head, legs, and eyes, only the thread-like mouth parts and anal plate being distinct. The

* *Aspidiotus perniciosus* Comstock. Family *Coccidæ*. See C. L. Marlatt, Bulletin 62, Bureau of Entomology, U. S. Dept. Agr., and the numerous publications of many of the experiment stations, listed in his bibliography.

scale itself is merely a waxy covering secreted by the insect beneath. The scale of the male is smaller and somewhat elongated, the nipple being at the larger end.

Injury by this species was first noticed near San José, Cal.,

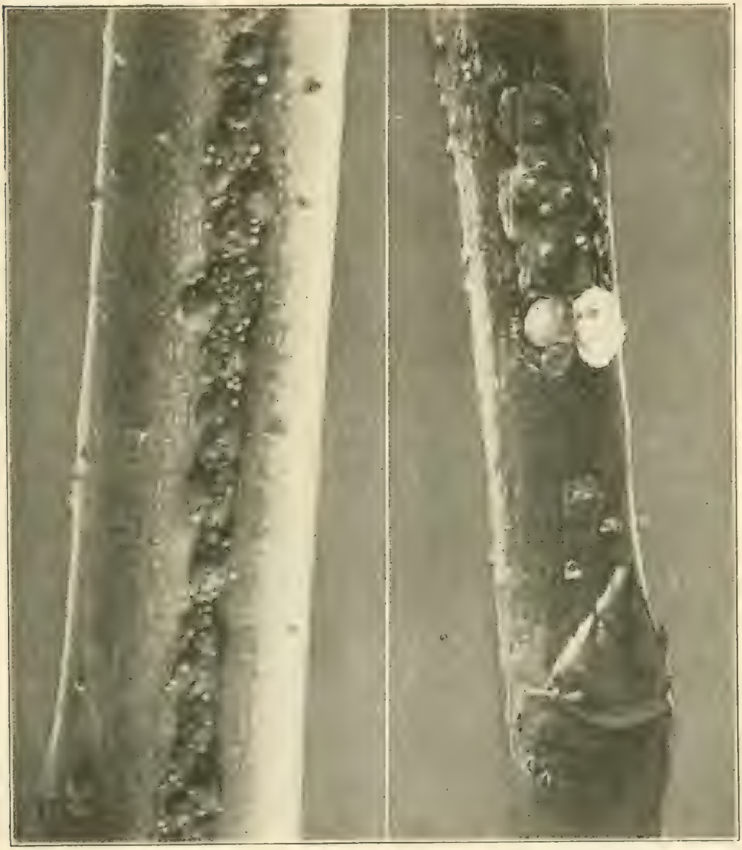


Fig. 390.—Peach twigs infested with the San José scale. On the twig at the right a scale has been turned back showing the female insect—enlarged. (After W. E. Britton.)

about 1880, where the scale was most destructive and was investigated by Professor J. H. Comstock, who first described it. About 1887 it was brought east on Japanese plum trees secured by Eastern nurseries and was distributed by them on young trees,

so that in 1893 it was discovered in orchards in Maryland and Virginia. Since then it has been spread on nursery trees to practically every State. Investigations made by C. L. Marlatt in 1901 showed that the insect is undoubtedly a native of east-central China, and was probably brought to this country on flowering peach or some ornamental plant.

Life History. The winter is passed as partly grown insects under the scales, which begin to feed with the bursting of the buds in spring. In the latter part of April the insects have become full grown in the District of Columbia, and the males emerge and fertilize the females. The male is a small, yellowish, two-winged fly, similar to Fig. 447*a*. The males emerge at night and are so small they are seldom seen unless reared. About a month later the females commence to give birth to live young and continue to do so for some six weeks. This species differs from most scales in having no egg stage, the eggs hatching in the body of the female. The young insects are very small, yellowish in color, and resemble small mites. They have six legs, a pair of antennæ, and a long thread-like beak through which the food is sucked, as shown in Fig. 391. The young insect moves about freely for from twelve to thirty-six hours, then thrusts its beak into the bark or fruit, and if a female does not move again. White, waxy filaments soon exude from over the body, and in a couple of days the insect is entirely covered by them, and as they mat down a scale is formed which conceals it. This young scale is whitish with a prominent nipple in the center. After the first molt, the females lose eyes, legs, and antennæ, for which they have no further use. Nourished by the sap of the plant the insect develops rapidly and is full grown in about a month. In the District of Columbia

FIG. 391.—Pear injured by the San José scale showing the discolored spots.

there are four or five generations a year, in the South there are probably more generations, while at the northern limit of the species there are two or possibly three generations, as breeding continues until after killing frosts. As with other small insects, it

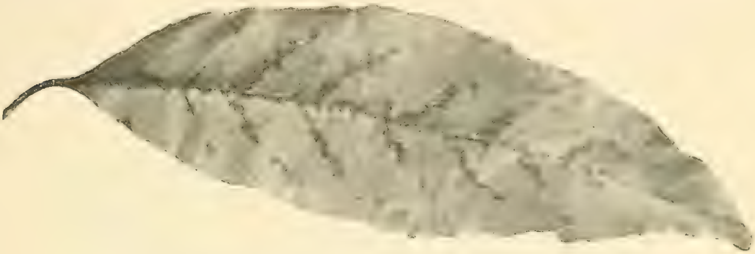


FIG. 392.—Peach leaf bearing San José scales along veins.

is the remarkable power of reproduction to which the destructiveness of the pest is due. Thus it has been estimated that at Washington, D. C., the progeny of a single female would number 3,216,080,400 by fall, if all were to survive. It is not surprising,

FIG. 393.—Adult female San José scale, with scale removed to expose the insect. (After Alwood.)

therefore, that a tree with but a few scales on it in spring will be covered by them and the fruit unfit for market in the fall, and that with these millions of little beaks pumping out the sap and poisoning the tissues a tree soon succumbs.

The pest has been spread mostly by being transported on nursery trees. Trees infested from the nursery will usually have more scales on the lower trunk, from which they will spread to the limbs, while those infested from neighboring trees will have more scales on the young wood. Where the pest is abundant the young insects are undoubtedly blown from tree to tree by the

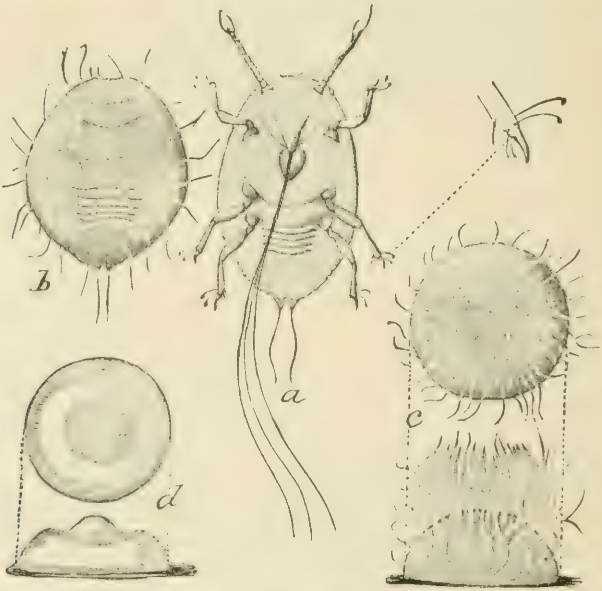


FIG. 394. Young larva and developing San José scale (*Aspidiotus perniciosus* Comst.): *a*, ventral view of larva, showing sucking beak and setæ separated, with enlarged tarsal claw at right; *b*, dorsal view of same, still more contracted and with the first waxy filaments appearing; *c*, dorsal and lateral views of same, somewhat contracted, illustrating further development of wax secretion; *d*, later stage of the same dorsal and lateral views, showing matting of wax secretions and first form of young scale—all greatly enlarged. (After Howard and Marlatt, U. S. Dept. Agr.)

wind, or they may be carried on the feet of birds or insects, or brushed off and carried by persons or teams working in the orchard.

The insect has been found on a long list of plants, but on many of them it is largely accidental. Injury is practically confined to plants of the *Rosaceæ*, which family includes all our common deciduous fruits. Of the orchard trees peach, pear, Japanese

plum, apple and quince are most injured in the order named, while cherry and European plum are less injured.

Control.—As yet no spray has been found for use in summer which will more than check the increase of the pest without injury to the tree, and summer spraying is resorted to only when

FIG. 395.—One of the most important native enemies of the San José scale, a little black ladybird-beetle (*Microweisea misella*): *a*, beetle; *b*, larva; *c*, pupa; *d*, beetles, larvæ, and pupæ, among scales—all greatly enlarged. (After Marlatt, U. S. Dept. Agr.)

winter treatment has been neglected or has proven inefficient. 10 or 15 per cent kerosene emulsion, dilute miscible oils, dilute lime-sulfur mixture, or whale-oil soap, 1 pound to 4 or 5 gallons, may be used for summer spraying.

On the Pacific Coast trees are very generally fumigated with hydrocyanic acid gas* for this and other scale insects, but the

* See C. W. Woodworth, Bulletins 122 and 152, Cal. Agr. Exp. Sta.; R. S. Woglum, Bulletins 79 and 90, Bureau of Entomology, U. S. Dept. Agr.

treatment has never come into favor in the East, principally, perhaps, because of the larger trees and the more scattered nature of the fruit industry.

Practically the only methods now used in the East consist in spraying the dormant trees with washes which penetrate the scales and destroy the insects. This may be done more effectively if the trees are pruned and headed in so as to reduce the wood to be covered. Rough bark should be scraped off so that the scales beneath may be reached. Badly infested trees should be sprayed in the the early winter as soon as they have hardened up and again in the spring just as the buds commence to swell. The spring spraying will suffice for trees slightly infested. Every bit of bark on the tree must be thoroughly wet, so none will escape. Lime-sulfur mixture seems to be the favorite wash for winter spraying at present, as it not only kills the scale, but aids in the control of many fungous diseases (see p. 50). Miscible oils are also extensively used and have a certain advantage on hairy apple shoots and on badly infested trees, as they are more penetrating and spread better. Kerosene or crude oil emulsion containing 20 to 25 per cent of oil was the first remedy to be used and is still extensively employed. Whale-oil soap, at the rate of 2 pounds to the gallon, applied hot, is effective, but is too expensive for large users. (See p. 50).

The Fruit-tree Bark-beetle *

If the outer bark is punctured by numerous small "wormholes" so that it looks as if it had been struck with a charge of bird-shot, it indicates the presence of the fruit-tree bark-beetle or some nearly related species (see p. 653). Usually more or less gum exudes from the holes, particularly on stone fruits. Diseased or weak-growing trees are most subject to attack, but occasionally serious damage is done to perfectly healthy trees, especially when young. Injury is largely due to allowing dead and dying trees to stand in the orchard, thus encouraging the

* *Scolytus rugulosus* Ratz. Family *Scolytidæ*. See F. H. Chittenden, Circular 29, Division of Entomology, U. S. Dept. Agr.

breeding of the pest in them and its spread to healthy trees. "Another form of injury is the destruction at the beginning of spring of small twigs, together with the leaves which they bear. The beetles are also reported to destroy leaves by boring into the base of the buds at their axils." The holes in the bark are caused by the exit of the small parent beetles and by their subsequent entrance to deposit eggs. The adult beetle is about one-tenth inch long, by a third as wide, and of a uniform black color, except the tips of the wing-covers and parts of the legs, which are red.

Life History.—The beetles emerge from the trees in April and May in the Middle States. The female burrows through the bark, and partly in it and partly in the sap-wood she eats out a vertical

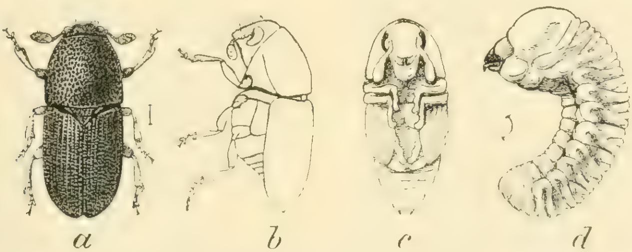


FIG. 396,—The fruit-tree bark-beetle (*Scolytus rugulosus*): *a*, *b*, beetle; *c*, pupa; *d*, larva—enlarged. (After Chittenden, U. S. Dept. Agr.)

gallery or brood chamber, along the sides of which at short intervals she gnaws out little pockets in which she places her eggs. The larvæ hatching from these eggs excavate little side galleries, which branch out and widen as the larvæ increase in size (Fig. 397). The larvæ become mature in about three weeks, when they form cells at the ends of their burrows and transform to pupæ, from which the adult beetles emerge about a week later. There are probably three generations a year in the Middle States according to Dr. Chittenden.

Were it not for the effective work of parasitic and predaceous insects which prey upon it, this insect would be a most serious pest. One of the most valuable of these is a little chalcis-fly *

* *Chiropachis colon* Linn.

of which Dr. Chittenden bred 92 specimens from 72 of the developing beetles, and we have frequently had twigs in which practically all of the developing beetles were parasitized.

Control. The most important point in the control of this and similar pests is to cut out and destroy all dead and diseased wood. Burn all prunings and trimmings. Affected trees should be liberally fertilized in the spring so that they may make a quick growth and better withstand the injury. Repellant washes have been advised for deterring the beetles from ovipositing. A thick soap wash containing a pint of crude carbolic acid to 10 gallons may be used. Professor Gossard advises whitewashing the trees in early spring, again in midsummer and lastly about October 1st, adding one-quarter pound of table salt or some Portland cement to make it more adhesive. He also reports killing the beetles in their burrows with an emulsion of carbolineum. "Emulsify by dissolving 3 pounds of naphtha soap in 3 gallons of water by boiling. While hot, add 1 gallon of carbolineum (arvenarius) and agitate as for kerosene emulsion with a force pump. Add four gallons of water for use and apply with a spray pump. Keep face and hands protected from this spray." The carbolineum is rather expensive, however, and does not seem to be much more effective than the whitewash.

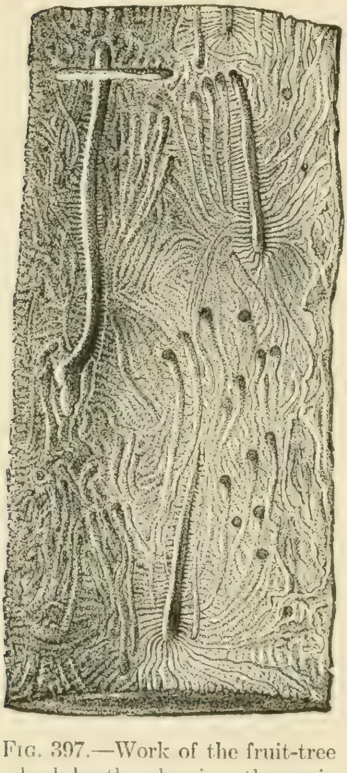


Fig. 397.—Work of the fruit-tree bark-beetle showing the main galleries, the side or larval galleries, and the pupal cells—slightly enlarged. (After Ratzeburg.)

The Buffalo Tree-hopper *

The work of the Buffalo Tree-hopper consists of a series of cuts or incisions in the limbs of fruit or shade trees, made by the female in the process of egg-laying, which result in very characteristic wounds. This injury is somewhat like that done by the periodical cicada or by tree crickets, but the scars are larger

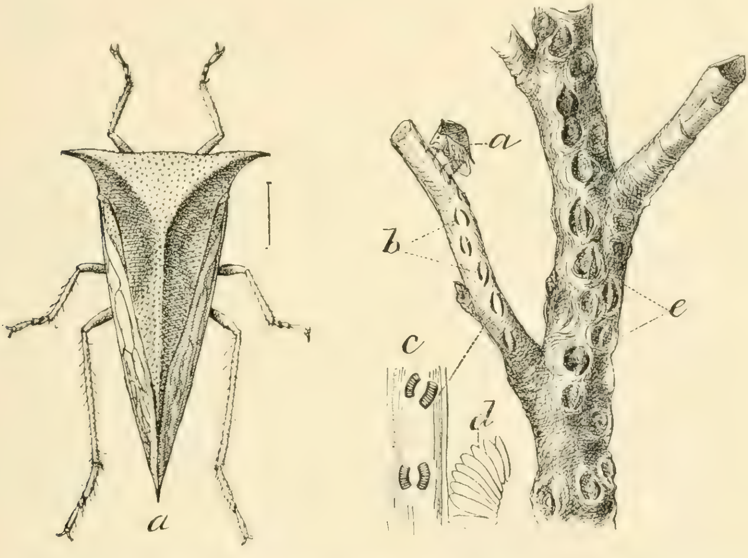


FIG. 398.—The buffalo tree-hopper (*Ceresa bubalus* Fab.): *a*, *a*, adult, enlarged and natural size; twig of apple showing recent egg-punctures at *b*; *c*, bark reversed with eggs in position; *d*, single row of eggs—enlarged; *e*, wounds of two or three years standing on older limbs. (After Marlatt, U. S. Dept. Agr.)

and are placed irregularly. When badly attacked the limbs of small trees sometimes become so scarred that they are badly stunted or may be killed. The parent of this mischief is a curious little grass-green insect, about three-eighths inch long, whose pronotum is broadly expanded into two sharp horns, which are

* *Ceresa bubalus* Fab. Family *Membracidæ*. See C. L. Marlatt, Circular 23, Div. Ent., U. S. Dept. Agr., and H. E. Hodgkiss, Tech. Bulletin 17, N. Y. Agr. Exp. Sta., p. 92.

fancied to be like those of the buffalo, as indicated by the common name of the insect. They are very common, frequenting all sorts of rank-growing vegetation, appearing in midsummer, and being most numerous in August and September.

Life History.—Egg-laying is commenced in August and is continued until killing frosts. The eggs are laid in two curved slits, with from six to twelve in each, as shown in Fig. 398, *c*, *d*. In making these slits the female cuts the bark between them entirely loose, so that the intervening wood soon dies, possibly to prevent the growth of the wood crushing the eggs. A large scar is thus formed which enlarges with each season's growth, and finally becomes an oval shape by the center dropping out. After a few years badly infested limbs become very rough, are easily broken by the wind and furnish vantage points for the attack of borers. The eggs hatch the next May or June. Like the adults, the young nymphs feed on all sorts of succulent vegetation, seeming to prefer the juicy annual plants even to the tender terminals of trees, the orchards suffering most being those grown up in weeds.

Fig. 399. — Nymph of buffalo tree-hopper—enlarged. (After Hodgkiss.)

Control.—By keeping young orchards well cultivated and free from weeds, the nymphs will have no food in early summer and will starve or leave for better feeding grounds. Patches of weeds near young orchards should also be destroyed. When trees are badly wounded by the egg punctures they should be well pruned and the prunings burned to destroy the eggs.

The Periodical Cicada *

"There is probably no insect that has attracted more general interest and attention in this country than the Periodical Cicada, or the so-called Seventeen-year Locust. The earliest settlers

* *Cicada septendecim* Linn. Family *Cicadidæ*. See C. L. Marlatt, Bulletin 71, Bureau of Entomology, U. S. Dept. Agr.; A. D. Hopkins, Bulletin 68, W. Va. Agr. Exp. Sta.

doubtless associated its vast noisy swarms with the devastating invasions of the Migratory Locust of the East. Hence the popular name locust, which has been used so long that it is doubtful if it will ever be discarded for the proper name—Periodical Cicada." They are quite different from the true locusts, or grasshoppers, however, for the latter have biting mouth-parts while the cicadas are true bugs and suck the juices of the plant through a tube-like beak. Some twenty-two distinct broods of the cicada have been distinguished, thirteen of which appear at seventeen-year intervals and seven of them appear at thirteen-year intervals, the former

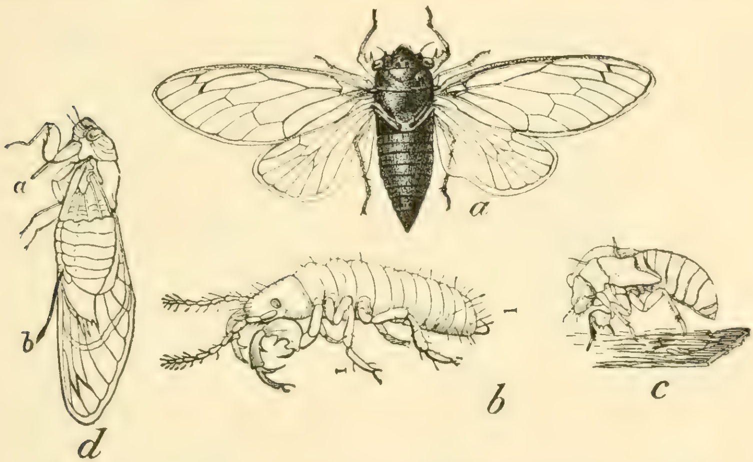


FIG. 400.—The periodical cicada (*Cicada septendecim* Linn.): *a*, adult; *b*, young nymph—enlarged; *c*, cast skin of full grown nymph; *d*, adult females showing ovipositor at *b*, and beak at *a*—natural size. (After Marlatt and Riley, U. S. Dept. Agr.)

being mostly in the North and the latter mostly in the South. Some one or more of these broods appears in every State east of the Rockies except Maine, New Hampshire and Vermont. Every year there is a brood emerging in some part of the country, and the different broods have been carefully mapped so that their emergence may be anticipated.

Life History.—The adults appear in immense swarms in late May or early June. "About four or five days after their first appearance," says Dr. Hopkins, "the males begin to sing"

filling the air with their shrill calls, which are produced by two drum-like membranes on the under surface of the first abdominal segment. "About eight or ten days later the sexes begin to mate, and in about four or five days more the females commence to deposit eggs. Each female is said to deposit from three to five hundred eggs in numerous ragged punctures made by her powerful ovipositor in the twigs of shrubs and trees, and sometimes in the stems of herbaceous plants. These hatch in about six or eight weeks from the time they are deposited and the young cicada larvae emerge and fall to the ground. They then burrow

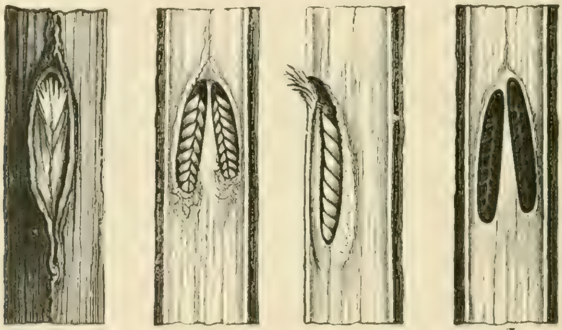


FIG. 401.—Egg mass of the periodical cicada: *a*, recent puncture, surface view, *b*, same, with surface removed to show arrangement of eggs; *c*, same, side view; *d*, egg cavity with eggs removed, and showing the sculpture left by the ovipositor—all enlarged. (After Riley, U. S. Dept. Agr.)

beneath the surface and enter upon their long menial existence in the ground, feeding on the liquids of roots and possibly subsisting on such nutriment as may be obtained from the soil itself. They change their position from time to time, and may rarely enter the earth for a distance of eight to ten feet or more," though usually within two feet of the surface. "By the twelfth or thirteenth year the larva attains its full growth and in time changes to the intermediate or pupa stage.* During the spring of the

* Dr. Hopkins and other writers commonly use the terms *larva* and *pupa* in describing the immature stages of the cicada, but there seems no reason for discarding the term *nymph* used for other Hemiptera, and which is certainly useful in distinguishing the immature stages of insects with incomplete metamorphosis from those with complete metamorphosis which have a true pupa.

fifteenth and sixteenth years great numbers of the pupæ may be found near the surface, and a few individuals may emerge during May and June of the sixteenth year. Early in April of the seventeenth yeai the pupæ commence to make preparations to emerge from the ground by excavating burrows or exit galleries to the surface. These exits are completed by the last of April. Ordinarily they extend only to the surface, and are kept open from a depth of a few inches to a foot or more. In some soils these exit holes are extended four or five inches above the surface by means of clay carried up from the subsoil, and are called cicada

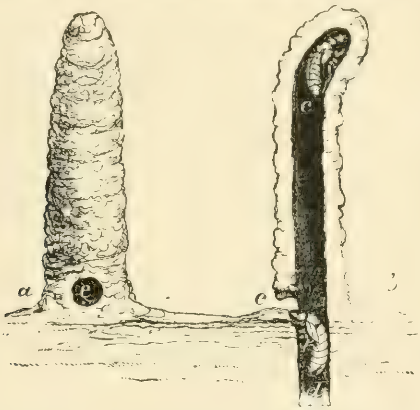


Fig. 402.—Pupal galleries or chimneys of the periodical cicada: *a*, front view; *e*, orifice; *b*, section of *a*; *c*, pupa awaiting time of change; *d*, pupa ready to transform—reduced in size. (After Riley, U.S. Dept. Agr.)

chimneys. The pupæ come from the ground in the evening and at night, usually between sundown and ten o'clock, and proceed to the nearest upright object, which may be a tree, the side of a building, fence, or weed stem—anything, in fact, upon which they can climb and expose their bodies to the action of the open air. In about an hour after emerging the skin on the back splits open and the adult insect works its way out (Fig. 403). The wings, which are short and soft at first, rapidly develop; the body, wings and legs harden, and by the following day the adult is ready to take flight and enter upon its short aerial life, limited to about thirty days. During this short period they feed but little, if at

all, the males devoting their time during the day to flying about and making a noise, while the voiceless females busy themselves depositing eggs. "If the young nymphs do any injury to the roots of trees or plants, it is very rarely perceptible. The adult females, however, are capable of causing serious injury to young fruit trees in orchards and nurseries by the numerous punctures in the twigs, limbs and main stems made by them in the act of

Fig. 403.—The full-grown nymphs of the periodical cicada in different stages of molting and the newly emerged adults with body and wings still soft and white.

ovipositing. The egg puncture makes an ugly wound, beyond which the twig dies, and the foliage of large trees on which hundreds of cicadas have oviposited turns brown, as if the tree had been scorched by fire. On young trees this results in destroying the growth of a year or two and misshaping the tree, and the scars which remain later furnish points of attack for borers and the woolly apple-aphis.

Just before the cicadas leave the ground they are attacked by hogs and also by disease. Upon leaving the ground they are at once assailed by a host of predaceous insects and various animals. One of the most valuable insect enemies is a large wasp (*Sphecius speciosus* Dru.), which may often be seen bearing the adults to its burrow, where they furnish food for her young. The English sparrow is remarkably fond of the adults and is the most valuable factor in exterminating them in cities and towns. It has been noticed that cicadas are much more likely to emerge from newly cleared land, and with the removal of the forests and cultivation of the land they are undoubtedly becoming more scarce.

Control.—There is no means of destroying the adults, but many of the pupæ may be destroyed by allowing hogs to run on land known to be infested during April and May of the year they emerge, where it is feasible to do so. Injury to young orchards may be avoided by not planting during the year or two previous to the emergence of a brood in the particular locality. Budding and grafting should also be avoided during the previous spring. Orchards should not be pruned the year before a cicada-year, so that there may be plenty of young wood in which they may oviposit and which may then be removed without injury to the tree. Evidently a knowledge of the time of appearance of each brood in different sections is of great importance and may be secured from the maps published (see Marlatt, l.c.). After all the eggs are laid the affected twigs should be pruned off in July and burned before the eggs have hatched.

The Fall Webworm *

The common fall webworm is so called because in the North, where there is but a single generation, its webs are abundant in August and September, in contrast to those of the tent caterpillar, with which they are often confused, which are found in the spring. The wings of the adult moths expand from one to

* *Hyphantria cunea* Dru. Family *Arctiidæ.*

$1\frac{1}{4}$ inches, and are either a pure milk-white, or more or less spotted with black, the number of spots being exceedingly variable. The full grown caterpillars are about an inch long, covered with long black and white hairs which project from numerous black tubercles.

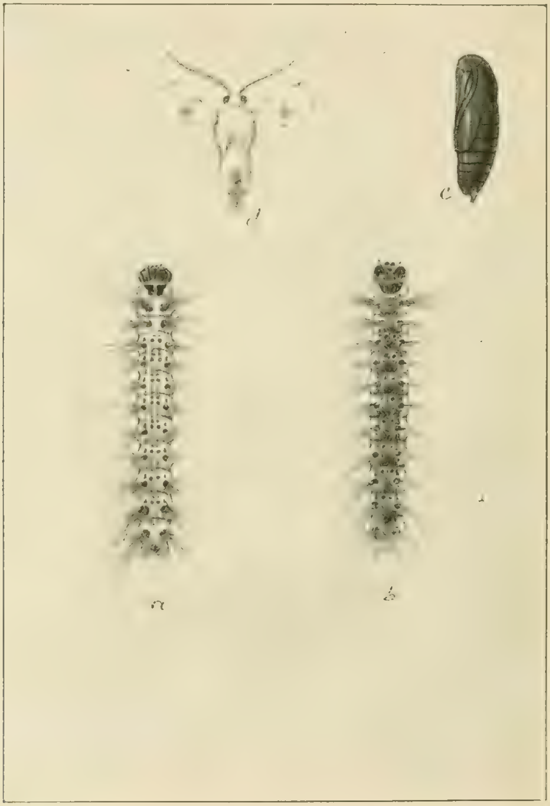


Fig. 404. - The fall webworm (*Hyphantria cunea* Dru.): *a*, light form of full-grown larva; *b*, dark form of same; *c*, pupa; *d*, spotted form of moth—all slightly enlarged. (After Howard, U. S. Dept. Agr.)

They are also quite variable in color, some being uniformly yellowish with black and yellow tubercles, while others have a dark stripe down the back and are almost black.

Life History.—In the North the moths emerge late in June and

Fig. 405.—Web of the fall webworm on apple, showing enclosed foliage and larvæ feeding within.

in July, and lay the eggs late in July. The eggs are deposited on the leaves in pale yellowish-green patches of 400 to 500, often covered with whitish down from the body of the female, and hatch in about ten days. The young larvæ are pale yellowish with brown markings and appear to be almost all head and hair. They at once spin a web over the foliage on which they are feeding, those from one egg mass feeding together and enlarging the web as necessary. In the North the webs are usually noticed in early August and are started at the tips of the limbs. Within them

FIG. 406. *Meteorus hyphantriæ*, a common parasite of the fall webworm; *a*, adult female; *b*, empty cocoon showing cap and suspending thread —enlarged. (After Riley, U. S. Dept. Agr.)

the surfaces of the leaves are eaten off until they are left dry and brown. When all the foliage on a limb has been consumed, the caterpillars leave the web, enclosing the dead leaves, and form a new web on a fresh branch, and thus the tree soon becomes covered with unsightly webs, which are often mingled so that the whole tree is webbed over. The web is easily distinguished from that of the tent caterpillar, as it is found later, and the tent caterpillar makes a relatively small web in the fork of a limb and never encloses foliage in it. The caterpillars become full grown in a

month to six weeks, and then find secluded places under the bark or in a hollow of the tree, in the rubbish at its base, or in a fence corner, or sometimes just under the surface soil, and there spin flimsy silken cocoons with which they mingle their own hairs. They then transform to small brown pupæ about one-half inch long, in which stage the winter is passed. In the Middle States and further south there are two generations, the moths appearing in April and May and laying eggs in late May and early June, the caterpillars from which become full grown by mid-July. The second generation of caterpillars appear in late August and September at about the same season as further north, and their pupæ hibernate.

Were it not for their parasitic enemies these caterpillars would be much more of a pest, and it is when the parasites become scarce that injury results. One of their most common and effective enemies is a little Braconid fly,* whose small brown cocoon (Fig. 406) is often found suspended from a twig or leaf. Many caterpillars are also killed by various predaceous bugs, and frequently they are killed off by fungous disease.

The fall webworm is a common pest of all orchard trees, and frequently extends its injuries to shade trees. The larvæ are not uncommon on cabbage, beets and a long list of garden crops. According to Dr. H. G. Dyar this species is confined to the South Atlantic States, but it has been confused with another species (*Hyphantria textor* Harris) by practically everyone, and it is still a question as to whether the two species are really distinct and if so how they are to be distinguished. If the latter form be a distinct species, it occurs throughout the United States and has the same habits.

Control.—The insect is readily controlled by spraying with any of the arsenicals when the work of the young larvæ is first noticed. Where orchards are sprayed for the codling moth there will be little trouble with the first generation, and fruit-growers will do well to make it a practice to spray in August where they are troubled with this and other leaf-eating caterpillars.

* *Meteorus hyphantriæ* Riley.

The Brown-tail Moth *

Although the Brown-tail Moth has become injurious only in Massachusetts, New Hampshire and Maine, it will be surprising if it does not become generally distributed, for during the past three years its nests have been imported on pear seedlings from France by nurseries in all parts of the United States and southern Canada, and possibly some have escaped even the most vigilant inspectors. It has long been a serious pest in parts of central and western Europe, whence it was introduced into Massachusetts about 1890, but did not attract attention until 1897. The female moth is pure white except the tip of the abdomen, which is golden brown and forms a large tuft or brush, which gives the insect its name. The wings of the female expand 1½ inches, the males being slightly smaller, and bear one or two streaks of brown on the under sides. The full-grown caterpillar is 1¼ inches long, dark brown, marked with a white dash on the side of each segment. The body is dark brown or blackish, well marked with patches of orange and covered with numerous tubercles bearing long barbed hairs. On the centre of the fifth and sixth abdominal segments are small retractile red tubercles. The tubercles along the back and sides are thickly covered with short brown hairs which give them a velvety appearance. These microscopic hairs are barbed and are the nettling hairs which, when

Fig. 407.—Winter web of the brown-tail moth—one-half natural size.

* *Euproctis chrysorrhœa* Linn. Family *Liparidæ*. See L. O. Howard, Farmers' Bulletin 264, U. S. Dept. Agr.; E. D. Sanderson, Bulletin 136, N. H. Agr. Exp. Sta.

they alight on the skin, produce a dermatitis much like that caused by poison ivy. As the cast skins are carried here and there by the

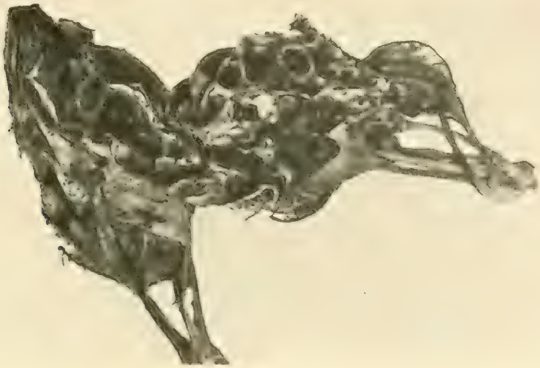


FIG. 408.—Winter web of the brown-tail moth cut open to show cells within.

wind and the young caterpillars drop from the trees, people are frequently badly poisoned where the pest becomes abundant, so that it is a serious public nuisance as well as a defoliator of

FIG. 409. Winter web of the brown-tail moth bearing young larvæ which have emerged before the foliage has appeared and are feeding on the dead leaves of the rest—two-thirds natural size.

fruit and shade trees. The caterpillars prefer fruit trees, pear, wild cherry, and apple being most relished, but become abundant

on almost all the common shade trees, except the evergreens, and particularly on oak.

Life History.—The moths emerge in midsummer. They are

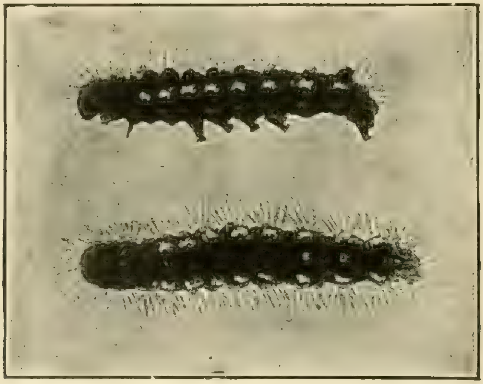


Fig. 410.—Full grown larvæ of the brown-tail moth—natural size.

strong fliers and are readily carried by the wind for many miles. They are attracted to lights in great numbers, so that they are

Fig. 411.—A mass of cocoons of the brown-tail moth attached to foliage.

more abundant in cities and villages. Late in July the eggs are laid on the terminal leaves, 300 or 400 being laid in an elongate

mass and covered with brown hairs from the tip of the female's abdomen. They hatch in about three weeks and the young larvæ feed on the surface of the leaves, leaving only the brown skeletons, so that badly infested trees turn brown in early fall. The caterpillars hatching from an egg mass feed together on adjoining leaves, which they soon commence to draw together with silken threads, and by the first frosts they have spun them into a tough web. This is attached to the twig by the old leaf stems, which are bound to it by silk. The web looks like a couple of dead leaves from a distance, but the leaves are merely the outer covering, and if the silk web be torn open, there will be found numerous small pellets of silk each enclosing from three to twelve of the little

FIG. 412.—The brown-tail moth (*Euproctis chrysorrhœa* Linn.): male above, female below—natural size.

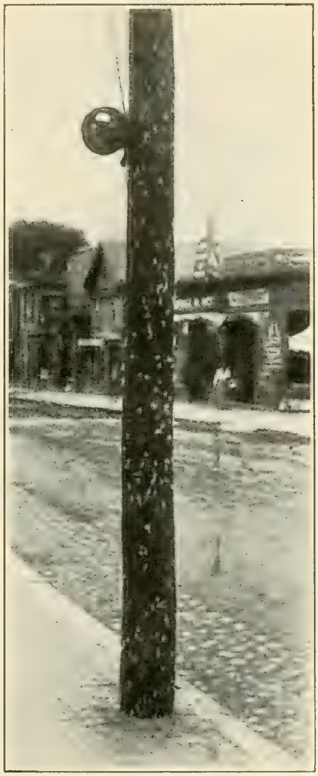


FIG. 413.—Brown-tail moths assembled on electric-light pole, Malden, Mass., July 12, 1905. (After Kirkland.)

partly grown caterpillars. The caterpillars emerge just as the buds burst in the spring and feed on the expanding foliage. Where abundant they soon strip a tree, for each of the nests harbors 400 or 500 little caterpillars. In five or six weeks they have become full grown and spin thin cocoons of white silk among

FIG. 414.—Egg masses of the brown-tail moth—natural size; caterpillars hatching from the mass on leaf at left.

the leaves, in which they transform to dark-brown pupæ. About three weeks later the moths emerge.

Several native parasites and predaceous bugs prey upon the caterpillars, but do not seem to materially reduce their numbers. In Europe there are several parasites which prey on all stages of the insect and which the State of Massachusetts with the coöperation of the U. S. Bureau of Entomology is introducing

in hope that they may ultimately be as effective in this country against both the brown-tail and gipsy moths. The most effective natural check of the brown-tail caterpillar is a fungous disease which often completely destroys large colonies, both in the spring and fall.

Control.—On fruit and shade trees the winter nests may be pruned off and burned in winter, thus preventing any injury the next spring, but this is impracticable on forest trees, which as a rule are not seriously injured. The repeated pruning often injures the trees, as it is difficult to cut all the nests without removing more of the new growth than is desirable. It is better, therefore, to spray the trees with arsenate of lead, 4 pounds to the barrel, as soon as the eggs hatch in late summer, and thus destroy the young larvæ before they have spun their winter webs.

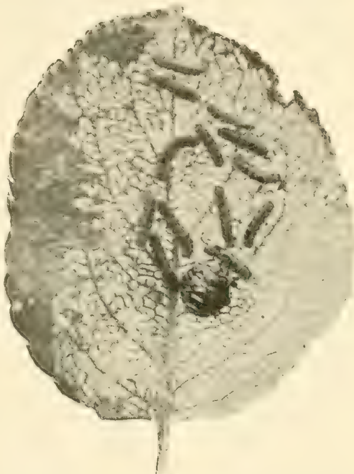


Fig. 415.—Young caterpillars of the brown-tail moth skeletonizing an apple leaf in late summer.

The Gipsy Moth *

History.—The Gipsy Moth has been known as a serious insect pest in Europe from the time of the earliest naturalists, the first authentic record being in 1662. It extends throughout the continent of Europe, over much of Asia and into Northern Africa, but is chiefly injurious in central and eastern Europe. It fre-

* *Porthetria dispar* Linn. Family *Liparidæ*. See Forbush and Fernald, "The Gypsy Moth," Mass. State Board of Agr. (1892); L. O. Howard, Farmers' Bulletin 275, U. S. Dept. Agr.; Annual Reports of the Mass. Superintendent for the Suppression of the Gypsy and Brown-tail Moths; E. D. Sanderson, Bulletin 136, N. H. Agr. Exp. Sta.; Rogers and Burgess, Bulletin 87, Bureau of Entomology, U. S. Dept. Agr., containing bibliography.

quently does serious injury there by defoliating large areas of forest and more frequently fruit and shade trees, but its ravages cease in two or three seasons, not to occur again for several years, like those of many of our native insects, such as the forest tent caterpillar and tussock moth. In 1868 the insect was brought to this country by Professor Leopold Trouvelot at Medford, Mass., in his experiments in silk producing. Escaping from him into the neighboring woodland, the insect increased gradually for several years before being noticed, but in 1890 had become such a serious

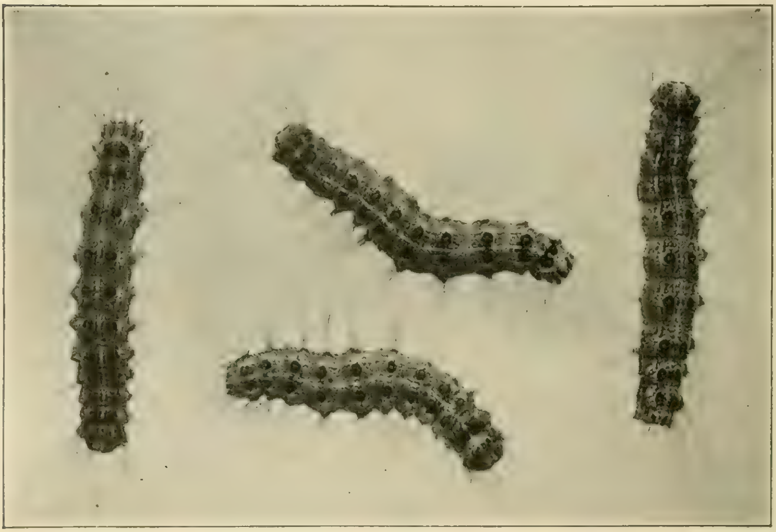


Fig. 416.—Gipsy moth caterpillars—natural size. (After W. E. Britton.)

pest throughout this and neighboring towns that the State of Massachusetts commenced the arduous task of its extermination. At this time the insect occurred in some twenty towns. For the next ten years it was successfully combated by the Massachusetts authorities, and in 1898 it had spread to but three towns not infested in 1890 and in many places it had apparently been exterminated. So slight was the injury that legislative appropriations were discontinued for four years, during which time the moth

spread over four times the area previously occupied and became so abundant that State action was again necessary. From 1905 to 1910 it spread throughout eastern Massachusetts and southern New Hampshire and Maine, and was found in two or three localities in Connecticut. Appropriations for its control have been increased until now the State of Massachusetts and the Federal Government are each appropriating $300,000 per annum and

FIG. 417.—The gipsy moth (*Porthetria dispar* Linn.): male above; female below—natural size. (After Forbush and Fernald.)

the total cost of combating it in New England must be considerably over a million dollars per year. As it is gradually spreading, there seems every reason to fear that it may ultimately invade other States.

Life History and Description.—The eggs are laid in July and August, in a mass of 400 to 500, covered with yellowish hairs from the body of the female. The mass is an irregular oval

shape $1\frac{1}{2}$ by $\frac{3}{4}$ inches, as shown natural size in the figure, and is deposited on the bark of trees, but where abundant, on fences, stones, buildings, etc. The eggs hatch about May 1, and each mass yields a swarm of young caterpillars, the bulk of which become full grown by midsummer. The mature caterpillar has a dusky or sooty-colored body. Along the back is a double row of five pairs of blue spots, followed by a row of six pairs of red spots, which readily distinguish this from any other common

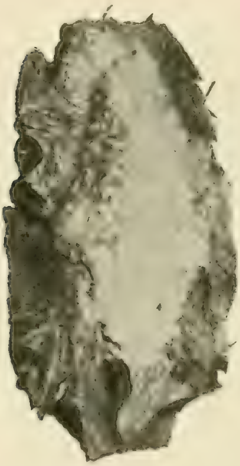


Fig. 418.—Egg mass of the gipsy moth on a bit of bark—natural size.

Fig. 419.—Pupæ of the gipsy moth, male and female—natural size.

caterpillar. The full grown caterpillar is about 3 inches long. Sometime in July or early August it spins a few threads of silk as a support, sheds its skin and changes into a pupa, sometimes enclosed in a thin cocoon, but often hanging pendant from its attachment. Characteristic light reddish hairs are scattered over the pupa The pupal stage lasts from ten days to two weeks, when the adult emerges. The moths emerge from the middle of July to late August. The male is brownish-yellow, varying to greenish-brown in color, the wings being marked with darker stripes, has a slender body and the wings expand about $1\frac{1}{2}$ inches.

It flies by day with a peculiar zig-zag flight. The female moth is nearly white with numerous small black markings, is heavy-bodied and sluggish. The wings expand about 2 inches, but fortunately the female is unable to use them for flight. Were it not for this the spread of the pest would have been much more rapid. After mating the moths live but a short time and do no damage themselves.

The pest is spread mostly in the caterpillar stage. The young

Fig. 420.—Woodland killed by being stripped by the gipsy moth caterpillars. Arlington, Mass, 1905.

caterpillars drop down on fine silken threads and may alight on vehicles which transport them to non-infested areas. When just hatched, the caterpillars have very long hairs, slightly expanded at the base, and these, with the silk which they spin out, serve to buoy them up in the air so that they may be carried for a considerable distance by a strong wind. Where they occur in myriads on high trees, it seems quite probable that the little

Fig. 421.—Egg masses of the gipsy moth on the trunk of an apple tree.

caterpillars may be carried by the wind for considerable distances, and that this is one of the chief means of spread. The egg masses may also be transported on merchandise or boxing, and the pest has undoubtedly become established in several localities in this way. A few cases of importation on nursery stock have been known.

The caterpillars will attack any of the fruit, shade or woodland trees, and where they become excessively abundant will destroy all green vegetation of almost any kind. It is essentially a pest of forest trees, but where it occurs it defoliates all of the common fruit trees. Coniferous trees are killed after being once stripped of their foliage, and deciduous trees usually die after four or five defoliations. Recent experiments show that the young caterpillars when they hatch from the eggs are unable to feed on conifers, so that growths of soft wood may be protected by keeping all hard-wood trees cut out.

Control.—In the orchard the gypsy moth is readily controlled by painting the egg masses with creosote in winter and by spraying the trees with arsenate of lead, 5 pounds per barrel, just as the eggs are hatching in the spring. Where this is practiced there is very little trouble in controlling it in orchards. Upon shade and forest trees the problem is much more difficult and the reader should consult the authors cited (footnote p. 563) as to the best means and apparatus. Although the pest is still confined to New England, it is such a serious one and there is so much danger of its spread elsewhere, that fruit-growers should be on their guard against it and should submit suspected specimens to the nearest entomologist. Should it be found in any other States, no expense should be spared to absolutely exterminate it before it may become established.

Canker Worms *

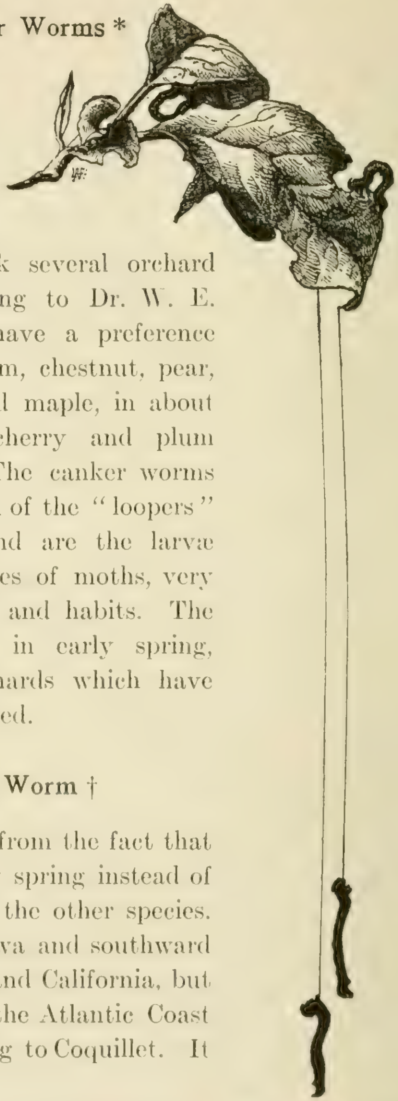


Fig. 422.—Canker worms dropping from foliage in characteristic attitudes. (After Bailey.)

Since the early colonial days Canker Worms have been among the best-known insect pests of the apple orchard, but they are general feeders and attack several orchard and shade trees. According to Dr. W. E. Britton they "seem to have a preference for the foliage of apple, elm, chestnut, pear, oak, hickory, box-elder, and maple, in about the order named," and cherry and plum are recorded by others. The canker worms are among the most common of the "loopers" or "measuring worms," and are the larvæ of two nearly related species of moths, very similar in both appearance and habits. The larvæ defoliate the trees in early spring, particularly in old sod orchards which have not been cultivated or sprayed.

The Spring Canker Worm †

This species is so called from the fact that its eggs are laid in the early spring instead of in the fall, as are those of the other species. It occurs from Maine to Iowa and southward to Texas, and in Colorado and California, but has not been rep rted on the Atlantic Coast south of New Jersey according to Coquillet. It

* Family *Geometridæ*. See D. W. Coquillet, Circular 9, Div. Ent., U. S. Dept. Agr.; W. E. Britton, Biennial Report Conn., Agr. Exp. Sta., 1907–08, p. 777; A. L. Quaintance, Bulletin 68, Part II, Bureau of Entomology, U. S. Dept. Agr.

† *Paleacrita vernata* Peck. Family *Geometridæ*.

seems to be particularly injurious in the Mississippi Valley. The full-grown caterpillar is from three-quarters to one inch long, slender, and cylindrical, and has but one pair of prolegs on

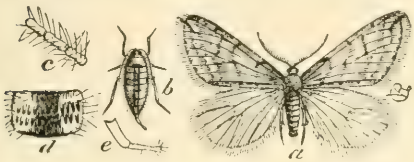


FIG. 423. — The spring canker worm (*Paleacrita vernàta*): *a*, male moth; *b*, female moth — both natural size; *c*, joints of female antenna; *d*, joint of female abdomen; *e*, ovipositor — enlarged. (After Riley.)

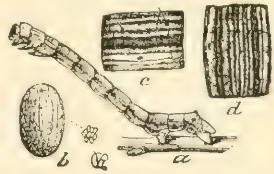


FIG. 424.—The spring canker worm (*Paleacrita vernata*): *a*, larva—natural size; *b*, eggs—natural size and enlarged; *c*, side view of segment of larva; *d*, dorsal view of same — both enlarged. (From Riley.)

the middle of the abdomen. The color varies from ash-gray to green or yellow, but the predominating color is dark greenish-olive or blackish, marked with narrow pale lines down the back

FIG. 425.—The female moths of the spring cankerworm—twice natural size, and pupæ—three times natural size. (After Quaintance, U. S. Dept. Agr.)

and a whitish stripe along each side. The wings of the male moths expand an inch, and are semi-transparent, brownish-gray, with three rather indistinct dark lines across the fore-wings. The

females are wingless and at the first glance look much more like spiders than moths. They are about one-third inch long, of a dull brown or grayish color with a dark brown stripe down the middle of the back.

Life History.—The moths emerge from the pupæ in the ground in March and April and the females climb up the trunks of the trees, where they place their eggs in irregular masses of about fifty, under loose scales of bark, in cracks in the bark, in crotches of limbs, etc. The individual eggs are yellowish-green, turning quite dark just before the larvæ hatch, of an oval shape, and about one-thirty-fifth inch long. The eggs hatch in about a

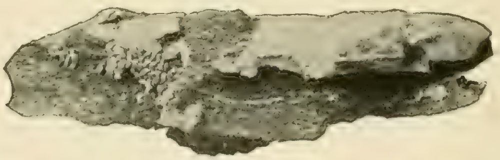


Fig. 426.—Eggs of spring canker worm—twice natural size. (After W. E. Britton.)

month and the young caterpillars commence to feed on the leaves just as they are expanding, at first eating small holes through them, but later devouring all but the midribs. The young caterpillars have a habit of dropping from the trees and hanging suspended on strands of silk. In four or five weeks they have become full grown and enter the soil to a depth of 2 to 5 inches, where they hollow out earthen cells, which they line with a little silk and in them change to pupæ, in which stage the summer and winter is passed. The pupa is nearly one-third inch long, light brown in color, somewhat pitted, and the male pupa bears a simple spine at the tip of the abdomen.

The Fall Canker Worm *

The Fall Canker Worm seems to be the more common form in New England according to Dr. Britton and is a more northern species according to Coquillet, occurring through the North-

* *Alsophila pometaria* Harris. Family *Geometridæ*.

Central States and in Colorado and northern California. As its name indicates, it differs in life history in that the moths emerge in November and December, "often occurring in great numbers on foggy days during a thaw after the ground has been frozen." They are most numerous about the middle of November in Connecticut, although Dr. Britton states that when the ground freezes

FIG. 427.—The fall canker worm (*Alsophila pometaria*): *a*, male moth; *b*, female—natural size; *c*, joints of female antenna; *d*, joint of female abdomen—enlarged. (From Riley.)

in early fall and does not thaw, many of the adults do not emerge until March, when the life history would be identical with the last species. The eggs are laid in clusters of about 100, arranged in rows, each egg fastened on end, and are laid on the bark of the smaller branches or on the trunk. The egg is brownish-gray, rather darker than that of the spring species, and is shaped like

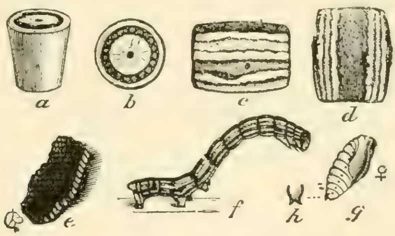


FIG. 428.—The fall canker worm (*Alsophila pometaria*): *a*, *b*, egg; *c*, *d*, side and dorsal views of larval segment—enlarged; *e*, egg mass; *f*, larva; *g*, female pupa—natural size; *h*, anal tubercle—enlarged. (From Riley.)

a flower-pot, the outer end being marked with a dark spot in the centre and a dark ring near the margin. The eggs hatch in late April and early May in Connecticut. The larvæ are very similar in general appearance to those of the spring canker worm, but may be easily distinguished by having two pairs of prolegs on the middle of the abdomen. The pupa is similar to that of the

other species, but is somewhat stouter and the spine at the tip of the abdomen of the male pupa is always forked. The cocoon is much tougher, contains more silk, and is therefore less easily crushed. The male moth is slightly larger than that of the other species, with longer antennæ, and the wings are firmer, less transparent and darker in color. The fore-wings are crossed by two whitish bands, the outer one being indented on the front margin so that it forms a distinct spot, and this outer band is seen on the hind-wings, though it is less distinct. The females are a uniform, ash-gray without markings, and with longer antennæ than those of the other species, the segments of which are about as broad as long, and are bare of hairs.

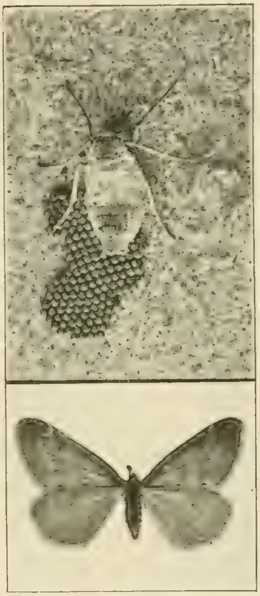


Fig. 429. — Wingless female moth and egg mass, and winged male moth of the fall canker worm — twice natural size. (After W. E. Britton.)

Control.—In old sod orchards where the pest is always worst, thorough cultivation will largely destroy the pupæ during the summer. The caterpllars may be quickly destroyed by spraying with arsenate of lead, 3 pounds, or Paris green, one-third pound, per barrel. The first spraying should be applied as soon as the foliage is fairly expanded and before the trees bloom, and the second should be given as soon as the blossoms drop. The first is the more important and one thorough spraying will usually suffice, as the young caterpillars are much more easily killed. Where for any reason spraying is not feasible, the females may be prevented from ascending the trees by encircling the trunks with bands of tanglefoot or some other sticky substance which they cannot cross. These bands should be applied in early October and late March, according to the species prevalent. The

tanglefoot may be applied directly to the bark of the tree, making a band two inches wide by one-quarter inch thick. Printer's ink, bodlime, and caterpillar-lime (raupen-lime) are often used, but should not be placed on the bark. A narrow band of cotton batting should be run around the tree and covered with a

Fig. 430.—Canker worm moths and egg masses caught on sticky band. (After W. E. Britton.)

strip of building paper 4 to 6 inches wide, on the centre of which the sticky band should be placed, thus preventing any injury to the bark by the material. Where spraying and cultivation are customary canker worms rarely become troublesome.

The Plum Curculio *

Throughout the States east of the Rocky Mountains, the Plum Curculio is one of the worst pests of the common stone and pome fruits. Its larva is the common white " worm " found in peaches, plums, and cherries, while apples and pears are scarred and gnarled by the feeding and egg punctures made by the adults. It is a native insect which breeds on wild plums, wild crab-apples and hawthorns. The adult is a thick-set snout-beetle about one-quarter inch long, brownish in color, marked with gray and black, and with four black ridged tubercles on the wing-covers.

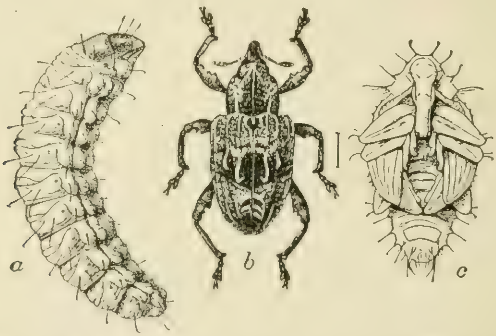


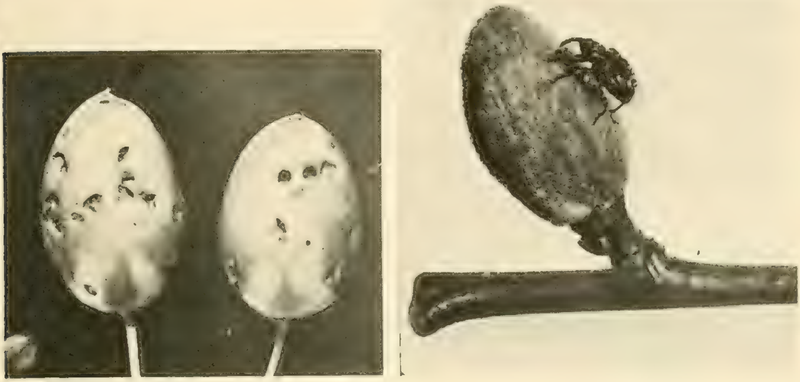
Fig. 431.—The plum curculio (*Conotrachelus nenuphar* Herbst.): *a*, larva; *b*, beetle; *c*, pupa—all much enlarged. (After Chittenden, U. S. Dept. Agr.)

The larva is a footless, cylindrical, whitish grub, about one-third inch long, with a small brown head, and usually lies in a curved position as in Fig. 431.

Life History.—The beetles hibernate under grass, leaves, and other trash on the ground in or near the orchard, or in neighboring woodlands, and commence to emerge just before the fruit trees bloom in the spring. They feed somewhat on the buds, unfolding

* *Conotrachelus nenuphar* Herbst. Family *Curculionidæ*. See C. S. Crandall, Bulletin 98, Ill. Agr. Exp. Sta.; S. A. Forbes, Bulletin, 108, *ibid.*; J. M. Stedman Bulletin 64, Mo. Agr. Exp. Sta.; E. P. Taylor, Bulletin 21, Mo. State Fruit Exp. Sta.; A. L. Quaintance, Yearbook U. S. Dept. Agr., 1905, p. 325; Circular 120, Bureau of Entomology, U. S. Dept. Agr.

leaves and blossoms, but mostly on the young fruit as soon as it is set; indeed, in New England the beetles do not emerge until



1 *2*

FIG. 432.—1, young plums showing crescent-shaped egg punctures of the plum curculio; 2, adult curculio on young peach—four times natural size. (After Quaintance, U. S. Dept. Agr.)

a week or two after the apple blossoms fall. The females commence to lay eggs in the young fruits as soon as formed. The

FIG. 433.—Plum curculio on young apple and egg punctures — enlarged.

FIG. 434.—The plum curculio — enlarged five times. (After Stedman.)

egg puncture of the plum curculio is shaped like a crescent and has given it the very apt name of "little Turk." The female

first eats out a small hole with her stout snout, and deposits a small oval, white egg in the cavity. She then cuts a small segment of the skin and flesh around it so that the growth of the fruit will not crush the egg, the whole operation taking from fifteen to thirty minutes. The life of a female averages about two months, during which time she will lay 100 to 300 eggs and probably makes as many more feeding punctures. The punctures made by the adults of both sexes in feeding are simple round holes like those in which the eggs are laid, but without the crescent

FIG. 435.—Larvæ of the plum curculio—enlarged five times. (After Stedman.)

marks. Frequently gum exudes from punctures on the stone fruits.

The egg hatches in from three to five days and the young larva bores into the fruit until grown, usually feeding around the pit in stone fruits. The larva becomes grown in from twelve to eighteen days (in peaches) according to Quaintance, but in central Illinois in fallen apples it requires from twenty to twenty-six days according to Crandall. When full grown the larva leaves the fruit and enters the soil, where it forms a small cell an inch or two below the surface, in which it transforms to a white pupa. Three or four weeks elapse before the emergence of the adult

beetles; the first emerge about ten weeks after the apples blossom, the majority appear two or three weeks later, and the rest continue to emerge until October. If the weather is dry the beetles may remain in the cells much longer than normally, while a shower will bring out numbers of them. Upon emerging the beetles feed upon the ripening fruit. In many sections the injury to apples by the feeding punctures then made is worse than the spring injury, as the surface of the fruit is injured and entrance places for rot are furnished. The beetles average about one puncture a day for six weeks after emergence in central Illinois and commence to enter hibernation with the first frosts. In New Hampshire we have seen no evidence of injury by the beetles in late summer or fall.

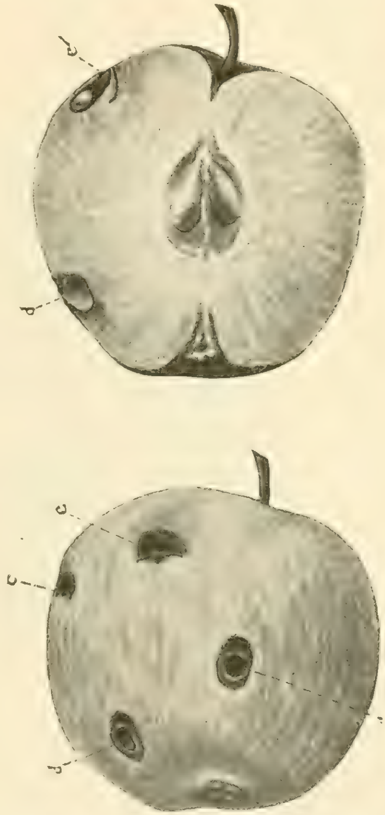


Fig. 436. —Work of the plum curculio on apple: *d*, feeding punctures from surface and in section; *e*, egg puncture from surface; *e′*, same in section—all enlarged. (After C. S. Crandall.)

Injury. — Injured plums and peaches usually drop to the ground, or if they remain on the tree, ripen prematurely, and rot more quickly. Cherries stick to the tree, but the fruit is often small and gnarled from the egg-scars, or eaten out by the larva. In apples the larvæ only develop in those which drop to the ground, the rapid growth of the apples probably crushing the eggs. The

egg-scars and feeding-punctures cause apples to become gnarly, this being particularly true of summer varieties, which are often rendered worthless, and even winter sorts are blemished by the scars which also furnish points of attack for rots.

Control.—Frequent cultivation while the pupæ are in the soil in midsummer will throw them to the surface and crush many of them, and has been found to aid materially in the control of the pest. As the larvæ often develop in the fallen fruit, it is well

Fig. 437.—Jarring trees over a curculio catcher. (After Slingerland.)

to gather it every few days and destroy it before the larvæ have left it to pupate, which will also aid in the control of other fruit pests. The beetles have a habit of "sulling," "playing possum," or feigning death, when suddenly disturbed, and will drop to the ground if a limb is jarred. This has given rise to the common practice of jarring peach, plum, and cherry trees and col.ecting the beetles on frames beneath them. This may be done with simple frames covered with canvas, a frame being placed on either side the tree and a flap extending from one over the edge of the other, from which the beetles are picked up, or a regu'ar curculio-

catcher such as has been commonly used in New York may be more convenient. This is used as shown in Fig. 437, the frame being covered with oil-cloth and slanting to a can containing kerosene for the destruction of the beetles which slide into it. The jarring should be done in the morning, as the beetles do not drop as readily in midday. During the past two years extensive experiments have been made in spraying with arsenate of lead to poison the beetles while feeding, which show that this is much the most satisfactory method of controlling the pest. By spraying with 2 to 3 pounds of arsenate of lead per barrel just after the blossoms fall, and again three weeks later on peaches, and with two more sprayings at intervals of ten days on apples, from 60 to 90 per cent of the injury from the curculio has been prevented. Only neutral, or nearly neutral arsenate of lead should be used on stone fruits, as a slight amount of soluble arsenious acid will burn the foliage badly. Paris green may be used with Bordeaux mixture on apples, but does not seem to be as effective as arsenate of lead, and is not advised for stone fruits.

CHAPTER XXVII

INSECTS INJURIOUS TO THE APPLE AND PEAR

The Woolly Apple-aphis *

THE Woolly Aphis is one of the most destructive pests of young apple orchards, and as it works mostly upon the roots it often escapes detection until the tree is badly injured or killed.

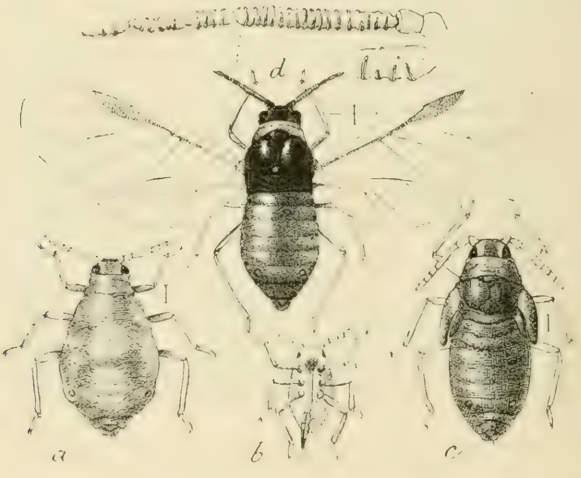


FIG. 438.—The woolly apple-aphis (*Schizoneura lanigera* Hausm.): *a*, agamic female; *b*, young nymph; *c*, last stage of nymph of winged aphis; *d*, winged agamic female with enlarged antenna above.—all greatly enlarged and waxy excretion removed. (After Marlatt, U. S. Dept. Agr.)

The aphides will be found clustered in bluish-white, cottony masses, looking like patches of mold, on the smaller twigs, par-

* *Schizoneura lanigera* Hausmann. Family *Aphididæ*. See C. L. Marlatt, Circular 20, Div. Ent., U. S. Dept. Agr.; R. I. Smith, Bulletin 23, Ga. State Board of Ent.; Gillette and Taylor, Bulletin 134, Colo. Agr. Exp. Sta., p. 4; C. P. Gillette, Journal of Economic Entomology, Vol. I, p. 306.

ticularly water-sprouts, and around wounds or scars on the trunk or limbs. Their presence in these places is always an indication that others are feeding upon the roots, where they cause gall-like swellings, so that the roots soon become a mass of knots and die in a year or two if the injury continues. When badly attacked a tree becomes sickly, the foliage turns yellow, and if not killed outright by the aphides, it falls an easy prey to borers and other pests. Injury seems to be worse on light soils and not so severe on heavy soils. Whether the insect is a native or European species is a matter of dispute. In Europe it is called the "American blight," and was described from Germany in 1801. It has now become distributed all over the world on nursery stock, which forms the principal means of its dissemination.

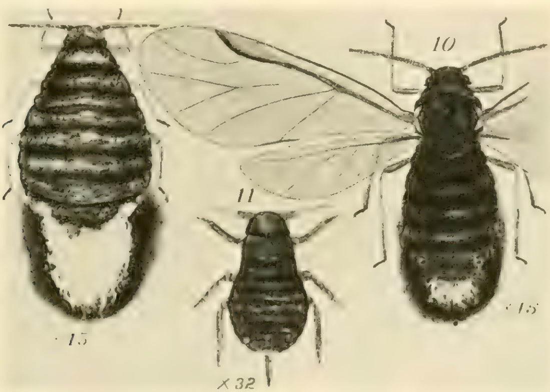


FIG. 439.—The wooly apple-aphis: at left, apterous viviparous female; 10, fall migrant; 11, over-winter young. (After Gillette and Taylor.)

Life History.—On infested trees aphides will be found in all stages of growth on the roots in early spring. On the trunk, under bits of bark or under the dead bodies of those killed the previous fall, will be found numerous small aphides which have hibernated there, though in the North these may be killed out during severe winters. As the buds begin to open, the aphides on the trunk locate on tender new bark and commence to feed, and many migrate from the roots to the top at about the same

time. They are not usually detected until they have multiplied sufficiently to make small white patches on the bark or leaves which look like mold. During the spring and summer all are wingless females, not over one-tenth inch long, of a reddish-brown color and covered with a white, waxy secretion, given off in threads from the abdomen so as to form a cottony mass over the colony.

These females produce from 2 to 20 young per day, which

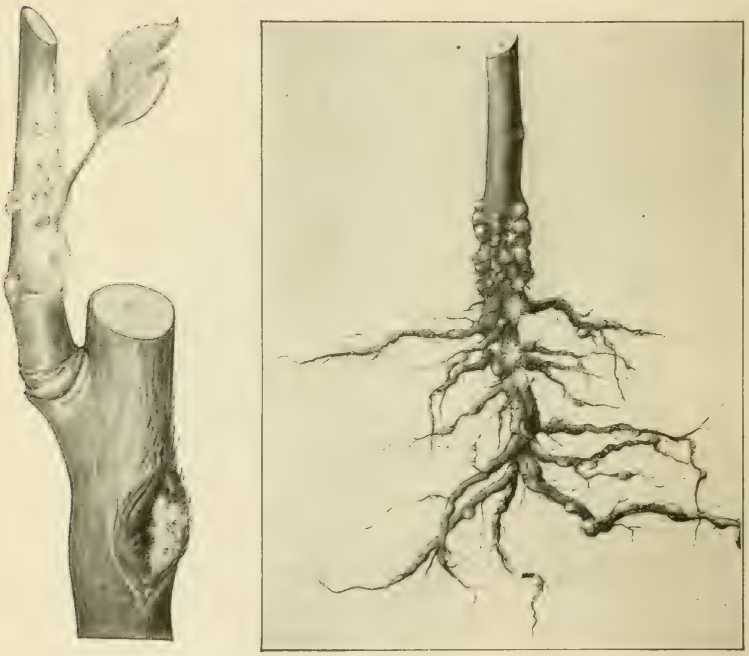


Fig. 440.—The woolly apple-aphis: at left, colonies on twig and in scar on an apple limb; at right, crown and root of young apple tree, showing characteristic swellings produced by the root aphides. (After Alwood.)

become full grown in from eight to twenty days according to Alwood,* 100 or more probably being produced in two weeks. Reproduction continues on both tops and roots except as checked by the cold of winter, the aphides becoming most abundant in midsummer. Early in the fall a generation of winged aphides

* Bulletin 45, Va. Crop Pest Commission, p. 12, Special Bulletin, Va. Agr. Exp. Sta.

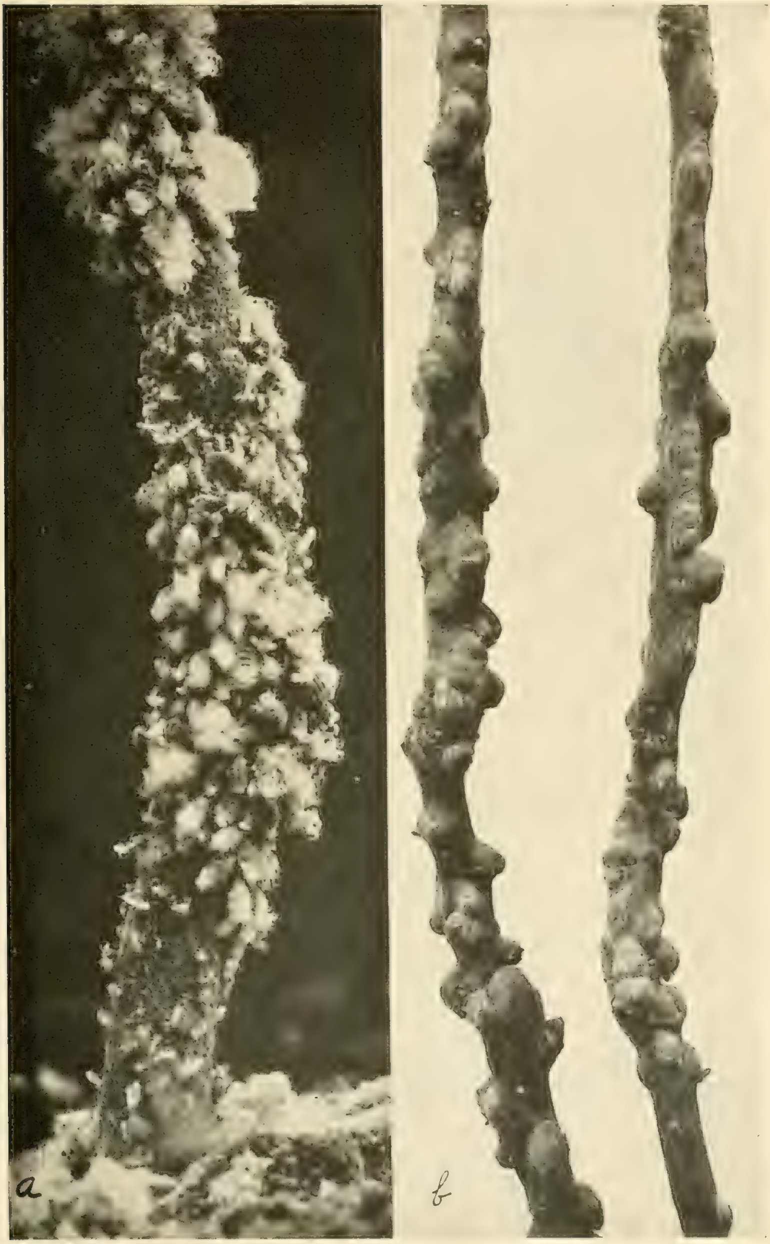


FIG. 441.—Woolly apple-aphides on stem of seedling tree and swellings made on roots slightly enlarged. (After Rumsey and Brooks.)

appears, which migrates to other trees. They are about one-twelfth inch long and have a wing expanse of one-quarter inch. They

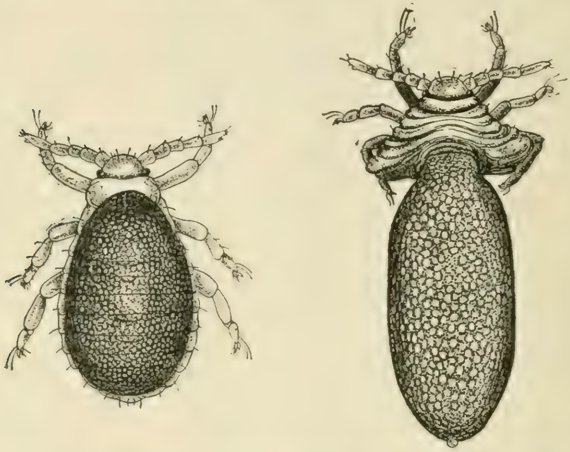


Fig. 142. Sexual female of the woolly apple-aphis, showing egg before and after extrusion—greatly enlarged. (After Alwood.)

appear to be black, but the abdomen is really a dark yellowish or rusty brown color when closely examined, and bears more or less of the waxy secretion on the tip. Each of these winged

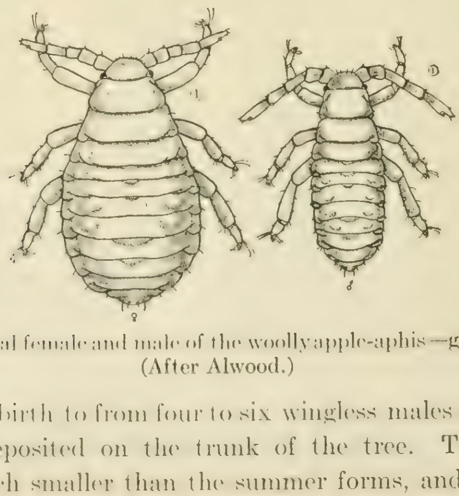


Fig. 143.—Sexual female and male of the woolly apple-aphis—greatly enlarged. (After Alwood.)

females give birth to from four to six wingless males and females, which are deposited on the trunk of the tree. The sexes are wingless, much smaller than the summer forms, and are without

beaks, so that they take no food. The female is a brown-ochre color, and the male dark green or greenish-brown and smaller, as shown in Fig. 443. They become full grown in about eight days, when they mate and the female then lays a single large black egg, which is deposited in the crevices of the bark on the lower part of the trunk. These eggs hatch in the spring and give rise to new colonies.

As they multiply large galls are produced on the roots, the tissue probably being poisoned by the mouth-parts of the insects. As a result the roots soon die and the aphides then migrate to the growing roots, so that their absence on the worst knotted roots does not indicate that they have forsaken the tree, but that they are on younger roots.

Control.—Nurserymen commonly apply a liberal amount of tobacco dust in trenches along the rows, which kills the aphides and acts as a repellant, as well as being worth half its cost as a fertilizer. This is probably the best practice in the nursery unless the aphides become abundant, when more vigorous treatment should be used, but tobacco has not always proven a satisfactory treatment for orchard trees, though used with apparent success in some instances. The aphides may be destroyed on the foliage by spraying with 7 per cent kerosene emulsion, miscible oils diluted 30 to 40 times, whale-oil soap, 1 pound to 6 gallons, or tobacco extracts, "black leaf" being used 1 part in 70 of water. Whatever insecticide is used must be applied in a strong spray so as to thoroughly wet and penetrate the waxy covering of the aphides. A winter spray of lime-sulfur wash destroys the hibernating aphides on the trunk, and doubtless kerosene emulsion or miscible oils applied in early spring, as for the San José Scale, would be as effective, though the lime sulfur would probably also destroy some of the eggs. The trunks of trees known to be infested may be banded with tanglefoot or similar sticky materials as described for canker worms (p. 574) to prevent the aphides from migrating from the roots to the top. Where the aphides are abundant on the roots, the earth should be removed for 6 or 8 inches deep over the affected roots and 10 per cent

kerosene emulsion or dilute tobacco extract should be applied, using two or three gallons per tree, or enough to thoroughly wet the soil. Dilute miscible oil might be used in the same way. Boiling hot water may be similarly applied, but is hardly practicable for extensive use. Carbon bisulfide injected into the soil has been frequently recommended, but practical tests do not seem to demonstrate its efficiency. Badly infested nursery stock should be destroyed, and it will be a good practiceto dip all trees in hot soap solution, or lime-sulfur wash, to destroy any aphides as well as San José scale. It has been observed that trees grown on Northern Spy stock do not seem to be as badly injured, and the matter of the susceptibility of varieties should receive further study.

The Round-headed Apple-tree Borer *

The young apple orchard must be given frequent inspection to detect the work of the round-headed borers, for if they become established in the young trees it is difficult to kill them and they soon girdle the trunks. They are most injurious to apple and quince, less so to pear, and also infest wild thornapple trees and mountain ash. The species occurs generally east of the Rocky Mountains, but is not commonly injurious in the Gulf States. The presence of the borers may be detected by the retarded growth of the trees, with a yellowing of the foliage, and the sawdust like castings which the larvæ throw out from the entrances of their burrows, accompanied by a discoloration of the bark over the new burrows, and in early spring there is often a slight exudation of sap. Injury is most severe in neglected orchards, where grass and weeds are allowed to grow about the bases of the trees, as the beetle, which flies at night, seeks the concealment of the rank vegetation during the day. The parent beetle is a handsome insect about three-quarters inch long. The antennæ and legs are gray, the head and under surface of the body silvery white, and the upper surface is light brown with two longitudinal white stripes.

* *Saperda candida* Fab. Family *Cerambycidæ*. See F. H. Chittenden, Circular 32, Division of Entomology, U. S. Dept. Agr.; E. P. Felt, Bulletin 74, N. Y. State Museum, p. 23, which gives full bibliography to 1902.

Life History.—The beetles emerge from late May to the middle of July and the females soon commence to deposit their eggs. The female eats out a little slit in the bark, in which the egg is inserted and often pushed under the bark and then covered with a gummy substance. It is a pale rust-brown color, about one-third inch long, of a broad oval shape, and usually concealed on young trees. The egg hatches in two or three weeks. The young larvæ tunnel just under the bark on the sap-wood, usually working down toward the base of the tree, the bark over these burrows often

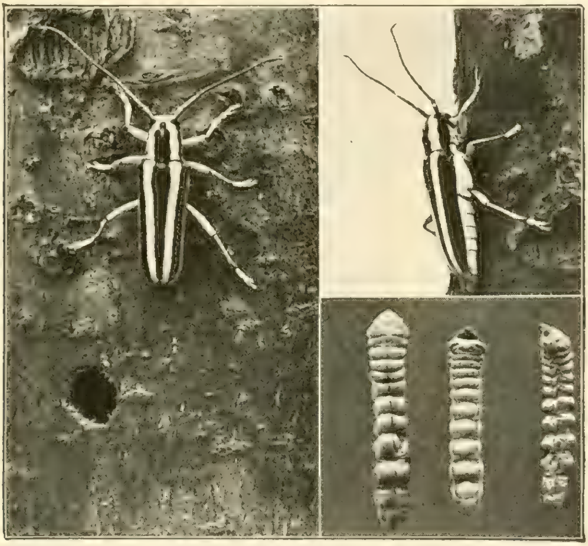


FIG. 444.—The round-headed apple-tree borer (*Saperda candida* Fab.) larvæ, adults, and exit hole—natural size. (After Rumsey and Brooks).

cracking the next spring, and the fine castings and borings sifting out. At the beginning of the second year the larva is about five-eighths inch long. The larva continues in the sap-wood during the second season, and it is at this time the most serious damage is done, for where several occur in a tree they almost girdle it. The next season they penetrate into the heart-wood, and several of them will fairly riddle a small tree with their cylindrical borrows. The full-grown larva continues this burrow

out into the bark, often cutting clear across a tree. The upper part of the burrows are stuffed with fine borings and the lower part with long wood fibres. The full-grown larva is a light yellowish, cylindrical grub, about three-quarters inch long. The head is small, legs are lacking, and the body tapers gradually from the thorax backward, the segments being quite constricted. The third spring the larvæ transform to pupæ and about three weeks later the adult beetles emerge through large round holes.

Control.—The females may be prevented from laying their eggs by wrapping the trunks with wire netting, building paper,

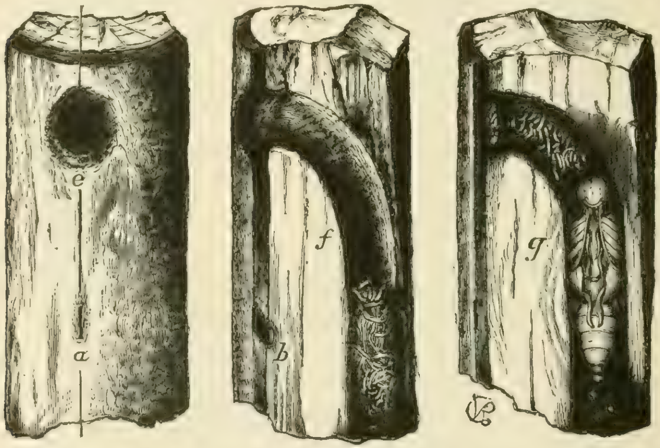


Fig. 445.—Work of the round-headed apple-tree borer: *a*, puncture in which egg is laid; *b*, same in section; *e*, hole from which beetle has emerged; *f*, same in section; *g*, pupa in its cell. (After Riley.)

or wood veneer. If non-rusting wire netting is used it may be left on and will also protect the trees from mice and rabbits. The paper or wood wrappings should be applied about May 1st, and removed in late summer. They should be tied to the tree tightly just below the crotch and should extend an inch or two into the soil below. The wire netting should be held out from the trunk of the tree by a layer of cotton batting under it at the upper end. Various washes have been used to repel the beetles. Thick whale-oil or caustic soft-soap to which a pint of crude carbolic acid is added to every 10 gallons is often used and should

be painted over the trunk so as to form a thick coating. Others recommend a thick coating of whitewash to which a little Portland cement is added to make it more adhesive. These should be applied by the middle of May and as often as need be to keep the trunk covered until late summer. If the trees are gone over every fall and spring, the egg scars and burrows of the young larvæ may be detected and they may be cut out while still in the sap-wood, without much injury to the tree. When the borers get into the heart-wood it is almost impossible to dig them out without doing more injury to the tree, but they may sometimes be destroyed by injecting carbon bisulfide into the burrows and plugging the aperture with putty or clay. Where a tree has been nearly or quite girdled, it may sometimes be saved by bridge-grafting. Orchards kept free of grass and weeds and trees with smooth healthy bark are much less affected.

The Flat-headed Apple-tree Borer *

This species is more abundant than the preceding, but does less damage. It prefers trees which have been weakened or are diseased, and attacks almost all of the common orchard trees as well as numerous shade and forest trees, so that it is everywhere common. The species is found from southern Canada to Mexico. The larvæ live just beneath the bark, where they hollow out broad flat channels which extend slightly into the sap-wood. The infestation may be detected by the discoloration of the bark. Where abundant they will often completely girdle young trees, thus causing their death, and they are frequently found abundant under

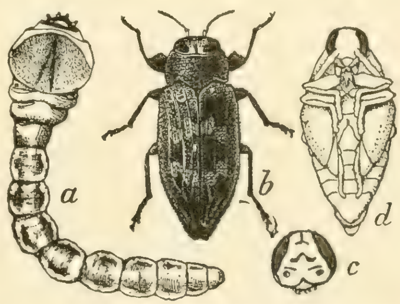


FIG. 446.—The flat-headed apple-tree borer (*Chrysobothris femorata* Fab.): *a*, larva; *b*, beetle; *c* head of male; *d*, pupa —twice natural size; (After Chittenden, U. S. Dept. Agr.)

* *Chrysobothris femorata* Fab Family *Buprestidæ*. See Chittenden, l.c.

the loosening bark of the dying limbs of large trees, as they infest not only the trunks, but the lower limbs. The adult beetle is about one-half inch long, dull metallic brown above, and the wing-covers taper sharply at the tip, somewhat like a click beetle. The wing-covers are ornamented as shown in the figure, and beneath them, as seen when in flight, the body is a bright metallic greenish-blue. The male is smaller and the head is green. The beetles are active during the heat of the day and may often be found on logs or injured trees.

Life History.—The beetles emerge from the middle of May until mid-summer. The eggs are deposited in crevices of the bark, several often being laid together. The eggs are yellowish, irregularly ribbed and about one-fiftieth inch long. The species receives its name from the shape of the larva, the thorax of which is very broadly expanded, so that it looks like the head, which is very small and almost concealed by it. The abdomen is much smaller and the whole body is flattened. The larva is about one inch long, and usually rests in the curved position shown in Fig. 446. The larva becomes full grown in a single year and in the South may pupate in November, but in the North does not pupate until the next spring, when it remains as a pupa about three weeks. The beetle emerges through an elliptical exit hole, in contrast to the round hole of the round-headed borer.

Control.—As this beetle is everywhere present, injury may always be expected if trees are not kept in a healthy condition, but if the orchard is well cared for it seldom does much damage. The same measures for preventing oviposition as suggested for the previous species are advised, but the repellant washes must be applied higher on the trunks and should extend to the lower branches as high as can be reached.

The Oyster-shell Scale *

Not infrequently young apple and pear trees are encrusted and killed by the Oyster-shell Scale, as are young poplars and maples.

* *Lepidosaphes ulmi* Linn. Family *Coccidæ.* See Quaintance and Sasscer, Circular 121, Bureau of Entomology, U. S. Dept. Agr., and references there given.

It is probably our most common scale insect, being almost always found on apple trees, on which it works on the bark or the twigs and trunk, reproducing even on old trunks, where the scales will be found under the loose bark and are undoubtedly a factor in causing the bark to slough off. All of the common orchard trees are occasionally infested but rarely injured, as are also maple, poplar, horse-chestnut, willow and lilac. Quaintance and Sasscer

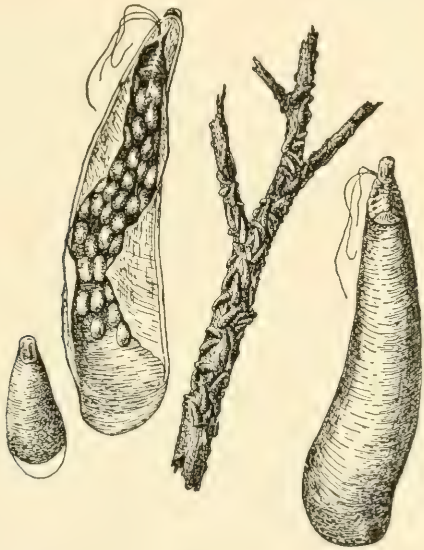


Fig. 447.—The oyster-shell scale (*Lepidosaphes ulmi* Linn.): *a*, female scales on twig; *b*, female scales from above; *c*, same from below showing eggs; *d*, male scale—enlarged. (After Howard.)

give a list of over 100 trees, shrubs, and plants upon which the scales have been found. The species is a cosmopolitan one, being introduced into this country at an early date and now being found in every State, and occurs throughout the world where the food-plants exist.

The mature female scale is about one-eighth inch long, of a dark-brown color, sometimes almost blackish, and shaped some what like an oyster-shell, as shown in Fig. 447. The male scale is

much smaller, and with but one cast skin at the anterior end, as shown in the same figure.

Life History.—If one of the female scales be turned over during the winter, numerous oval, white eggs will be found under it, with the shriveled body of the female insect tucked away at the anterior end. These eggs hatch a week or two after the apples blossom, producing small yellowish insects, which look like mites as they crawl over the bark, which they often give a yellowish

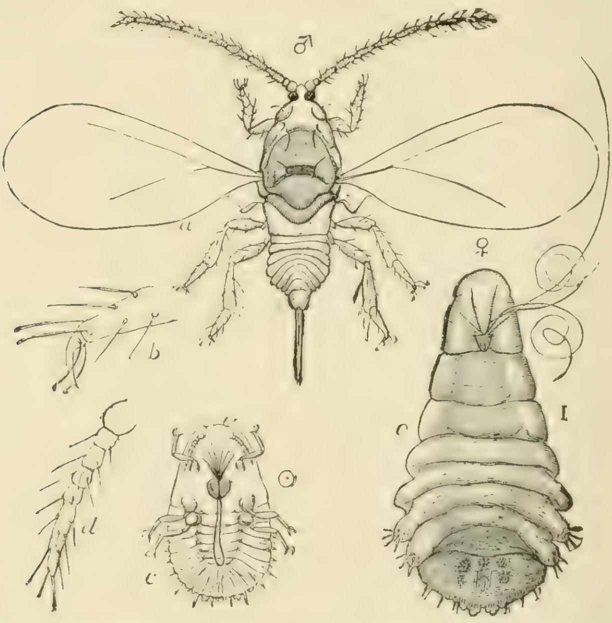


FIG. 448.—The oyster-shell scale: *a*, adult male; *b*, foot of same; *c*, young nymph; *d*, antenna of same; *e*, adult female taken from scale—*a*, *c*, *e*, greatly enlarged, *b*, *d*, still more enlarged. (After Howard, U. S. Dept. Agr.)

tinge where very abundant. The young insect is of microscopic size and is shown greatly enlarged in Fig. 448, *c*. It settles down after a few hours' wandering and begins sucking the sap from the bark. In a day or two long, white waxy filaments exude from over the body, which soon mat down and form the protecting scale, to which the cast skins are added when the

insect molts. The female loses her legs, antennæ, and eyes, after the first molt, and when full grown is an elongate, yellowish, jelly-like mass, being simply a "reproductive sack, with her sucking mouth parts, through which the food is taken, inserted in the tissues of the plant," as shown in Fig. 448, *c*. The females become full grown in about eight to ten weeks, when they lay from 40 to 100 eggs and then die. In the North there is but one generation a year, but from the District of Columbia southward there is a partial or complete second generation. When the male insects are full grown they emerge from the scales as two-winged flies, as shown greatly enlarged in Fig. 448, at *a*, fertilize the females and die at once.

Control.—See below.

The Scurfy Scale *

"The Scurfy Scale, while infesting a considerable number of plants (some 35 in number), is a less general feeder than the preceding species. It occurs principally upon rosaceous plants, such as the apple, peach, pear, plum, cherry, etc., and also on currant and gooseberry among cultivated plants, but seldom becomes so abundant as to cause particular injury or require specific treatment." It is especially common on apple and pear and less so on cherry and peach, though it has been observed as quite destructive to peach in the South, greatly stunting the trees, though none were actually killed. The female scale is a dirty-gray color, irregularly shaped as shown in Fig. 449, *c*. The male scale is much smaller, elongate, snowy white, and with three distinct ridges, Fig. 449, *d*. It is an American insect, being common from southern Canada to the Gulf States. The life history, as far as known, is practically identical with that of the last species.

Control.—As the last two species are practically identical in habits, they may be controlled by the same methods. Where the trees are sprayed with lime-sulfur wash for the San José

* *Chionaspis furfura* Fitch. Family *Coccidæ*. See Quaintance and Sasscer, l.c.

scale, there will be but little trouble with these scales, and where specific treatment is required for them experiments indicate that a thorough coating with the lime-sulfur wash while the trees are dormant, preferably in the spring just before the buds open, is one of the most effective remedies. The wash does not seem to kill the eggs, but to kill the young soon after hatching, and has been used successfully on both fruit and shade trees, but if there be frequent rains in late spring, so that it is washed off, or if the

FIG. 449.—The scurfy scale (*Chionaspis furfura* Fitch): *a*, *c*, females, *b*, *d*, males—*a*, *b*, natural size, *c*, *d*, enlarged. (After Howard, U. S. Dept. Agr.)

scales are very thick, it is not always entirely effective. In England a 3 per cent caustic soda wash has proven very satisfactory for killing the winter eggs. Recent experiments made by Professor R. A. Cooley in Montana * show that emulsions of linseed or cottonseed oils are very satisfactory when applied either in the spring or as the eggs are hatching, and were more effective than

* R. A. Cooley, Journal of Economic Entomology, III, p. 57; R. L. Webster, ibid. IV, p. 202.

other insecticides tested. These emulsions are prepared the same as kerosene emulsion (p. 48), using one gallon of the oil, and ½ to 1 pound of soap to 10 or 12 gallons of water. When the eggs are hatching and the young are crawling the trees may be sprayed with the above or 15 per cent kerosene emulsion, or whale-oil soap, 1 pound to 4 or 5 gallons of water. The effectiveness of the last two insecticides seems to vary according to local conditions, as they have proven satisfactory in certain experiments and of less value in others. As for the San José scale, the trees or shrubs to be treated should first be pruned of the dead and worst-infested wood, and loose bark scraped off, so that the bark may be thoroughly covered.

Apple Plant-lice *

Several species of aphides or plant-lice commonly infest the foliage of the apple, and less commonly that of the pear, and though they differ somewhat in appearance and habits they are sufficiently alike to be discussed together, as the same methods of control apply to all.

The Apple-aphis †

This is the common apple-aphis of Europe, and was first noticed in this country late in the last century, when it spread to all parts of the country within a few years, probably being distributed on nursery trees. Only young trees are usually much injured by this and the following species of aphides, old trees rarely being injured, except that where the aphides are excessively abundant they sometimes injure the young fruit, causing it to become stunted and misshapen. The foliage of young trees soon becomes covered with the vermin, which feed on the under surfaces of the leaves, causing them to curl up and then drop.

* See Sanderson, 13th Report, Del. Agr. Exp. Sta.; A. L. Quaintance, Circular 81, Bureau of Entomology, U. S. Dept. Agr.; Gillette and Taylor, Bulletin 133, Colo. Agr. Exp. Sta.

† *Aphis pomi* DeG. Family *Aphididæ.* See above references, and J. B. Smith, Bulletin 143, N. J. Agr. Exp. Sta.; C. P. Gillette, Journal of Economic Entomology, Vol. I, p. 303.

This curling of the foliage is more commonly caused by this species than any other, though the rosy apple-aphis has a similar effect. The aphides secrete the sweet honey-dew very profusely and so attract large numbers of ants, which feed upon it. The ants are a'ways found associated with them, and the presence of numerous ants on a tree is a good indication of aphides. The honey-dew soon covers badly infested foliage and upon it there

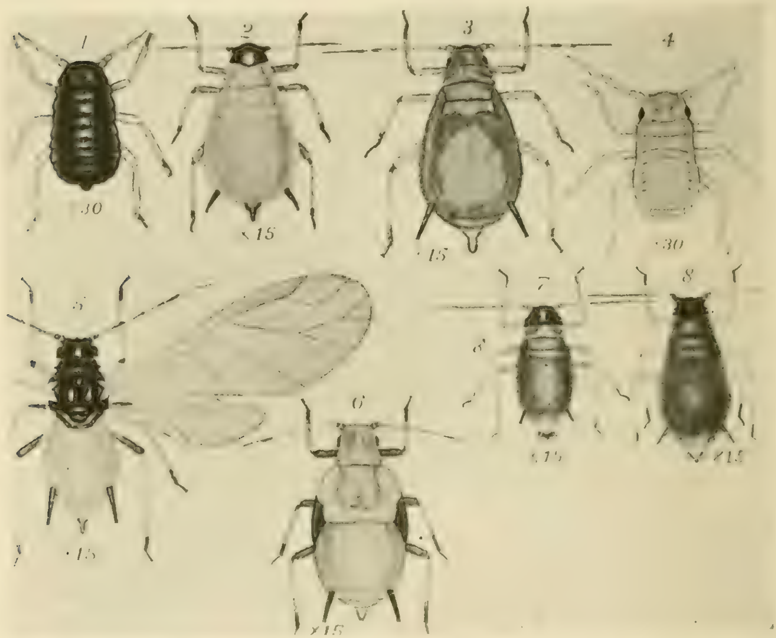


FIG. 450.—The apple-aphis (*Aphis pomi* DeG.): 1, young stem mother; 2, adult stem mother; 3, adult apterous viviparous female; second generation; 4, young female, second generation; 5, winged viviparous female of third generation; 6, pupa of preceding; 7 and 8, apterous male and oviparous female—all enlarged as indicated. (After Gillette and Taylor.)

grows a blackish fungus which gives the leaves a sooty appearance, often visible on the twigs after they drop, and a good indication of injury by this species. The full-grown wingless females are about one-twelfth inch long, and shaped as shown in Fig. 450. They are of a bright green color, though occasion-

ally yellowish, and the tips of the antennæ, honey-tubes, and tail are black. The winged female is slightly longer and the wings

FIG. 451.—The apple-aphis, winged viviparous female—greatly enlarged.

expand about one-quarter inch, the head is deep olive brown; the thorax is blackish, and there are three black spots on the

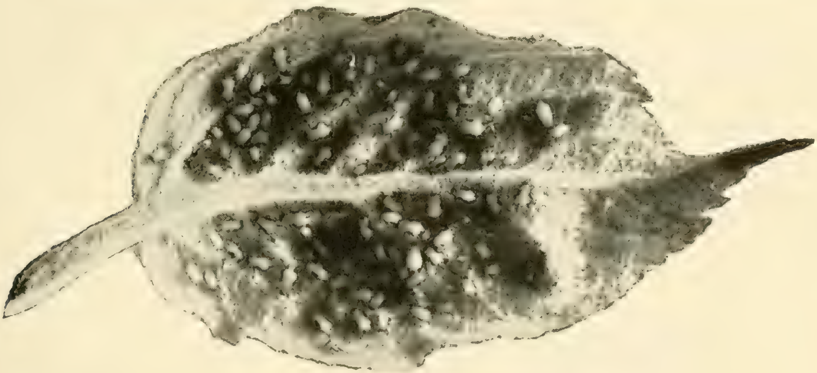


FIG. 452.—Nymphs of the apple-aphis, clustered on a leaf, showing developing wing-pads.

lateral margin of the abdomen, but otherwise it is colored like the wingless female.

Life History.—The minute, oval, shining black eggs are

to be found on the twigs during the winter, especially at the crotches and around buds and scars. They hatch just before the leaf buds open and the young aphides become full grown in two or three weeks, all of them being wingless. During the next two or three weeks each of these females will give birth to from 50 to 100 young, a few of which develop wings. All of the aphides

FIG. 453.—The apple-aphis; *a*, young tree partially defoliated by the aphis; *d*, winter eggs on twig.

of this second generation are also females, which give birth to live young without the intervention of males, which do not appear until fall. Their young develop in a week or ten days and most of them become winged and migrate to other trees. The development and reproduction continues in this fashion throughout the summer, both winged and wingless females being found in most colonies, though the size and coloration differ in the various

generations. Those which are to become winged may be distinguished after the third molt by the blackish wing-pads at the sides of the body. With the first frosts of fall the young develop into true males and females. Both are wingless, the male being much the smaller, has long antennæ, is yellowish or rusty-brown, and is very active, while the female is larger, moves more slowly and is lighter in color, but later becomes a very dark green. The sexes mate and the females lay 1 to 3 eggs in the places mentioned. All of the aphides die by late fall and the eggs remain to give rise to new colonies in the spring.

With the rapid multiplication above described it is not surpris-

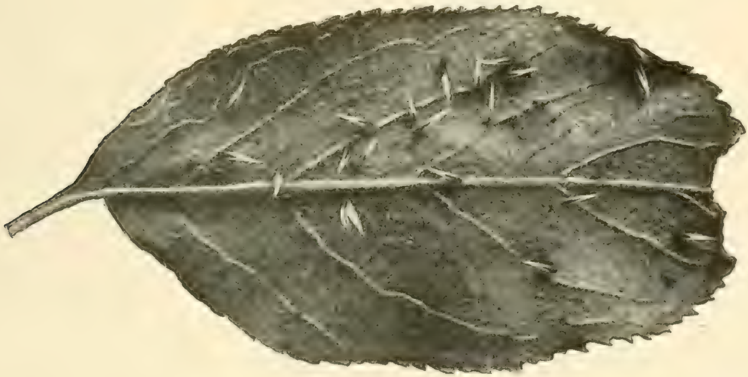


FIG. 454.—The apple-aphis, winged fall migrants on leaf—natural size.

ing that the foliage is soon covered with thousands of aphides, and that with so many sucking the sap the leaves soon curl up and drop. This is often a serious drain upon the vitality of young trees, stunting their growth, and so weakening them that they are more liable to be attacked by other insects and diseases, while the premature dropping of the foliage prevents the full growth of the tree and the proper hardening of the wood before winter. This species shows marked preference for certain varieties of apples and rarely injures others. Apple, pear and quince are the only fruit trees infested by this species, which lives upon them throughout the year.

The Rosy Apple-aphis *

This species is larger than the preceding, with a rounder body, and is commonly of a rosy color, though the wingless females vary from a salmon or tan color to slaty gray, purplish or black. It has been injurious only to apple in this country, where it has become widely distributed, but in Europe its native food-plants are various wild species of *Sorbus* and *Cratægus*. The wingless female is about one-tenth inch long, the head, thorax and margin of the abdomen being dark reddish-brown, and covered with a

FIG. 455.—The rosy apple-aphis (*Aphis sorbi* Kalt.): winged viviparous female greatly enlarged.

powdery substance which gives it a deep blue color, the middle of the abdomen being lighter yellowish. The antennæ and legs are whitish, marked with dusky. The honey-tubes are pale yellow, tipped with black, and are long and tapering. Between the eyes are two small tubercles, and on the middle of the two segments in front of the tail are a pair of similar small tubercles, which are quite characteristic of this species. When fully developed the female becomes much darker and distended with young, which

* *Aphis sorbi* Kalenbach. Family *Aphididæ*. See Sanderson, and Gillette and Taylor (*Aphis pyri* Boyer), cited above; and W. E. Britton, 9th Report, State Entomologist of Connecticut, p. 343.

may be seen through the abdomen. The winged female is about the same length, the head, thorax and honey-tubes being black, and the abdomen yellowish-red. The winged females in the fall differ from those of the spring in lacking the small tubercles between the eyes, but both spring and fall winged females have the two pairs of small tubercles in front of the tail. They also differ in having a large black splotch on the centre of the abdomen, bands across the terminal abdominal segments, and spots along the sides, also black. The male is winged and similar to the winged viviparous females which migrate back to the apple in fall. The egg-laying females are wingless, very much smaller than the summer forms, and light lemon-yellow in color.

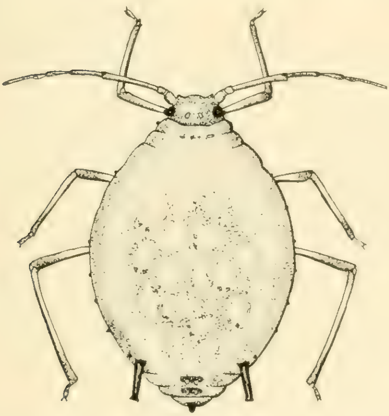


FIG. 456.—The rosy apple-aphis, wingless viviparous female—greatly enlarged.

Life History.—The eggs occur on the twigs, as do those of the last species, hatch about the same time, and the first two or three generations develop on the app e in the same manner. Like the last species, the third generation is mostly winged females and migrate from the apple to some unknown food-plant, on which they pass the summer. The winged females return to the apple foliage in the fall and then give birth to young, which develop into the true males and females, which may be found laying their eggs in company with the last and other species.

This species curls the leaves, as does the apple-aphis, and is likewise accompanied by ants. Dr. Britton states that "the rosy apple-aphis . . . seems especially prone to attack the fruit spurs and inner portions of the tree-top rather than the terminal twigs and exterior part," and that it "affects seriously the growth of the fruit," preventing its growth and development, and causing it to be gnarled and irregular in shape, similar to the damage sometimes observed by the last species.

The European Grain-aphis *

This species is found on the apple, pear, quince and plum in the spring and fall and on the small grains and various grasses during the summer. Until recently it has been the more common form on apple in the East, but is not now so numerous as the apple-aphis. It is an old European species and was evidently imported to this country at an early date, as it is widely distributed throughout the United States. The wingless females are distinctly

FIG. 457.—The European grain-aphis (*Siphocoryne avenæ* Fab.): wingless viviparous female, and egg-laying or oviparous female—greatly enlarged.

smaller than the previous species, and are of a light green color, marked with transverse diamond-shaped bands of darker green across the abdominal segments. The honey-tubes are shorter, distinctly enlarged at the middle and flared at the tip, which

* *Siphocoryne avenæ* Fab. Family *Aphididæ*. See Th. Pergande, Bulletin 44, n. s., Div. Ent., U. S. Dept. Agr., p. 5 and authors cited above. The author described this species as *Aphis fitchii* in 1902, and although there seems to be no question that it feeds on grains and grasses during the summer, there are several reasons for believing that there are either two species or that the life history has not been sufficiently observed. Thus in some sections it is exceedingly common on grain but rare on apple, and in others just the opposite condition is found. Further observation may solve these anomalies.

distinguish the species of this genus. The winged female has the head and thorax blackish, and the abdomen yellowish-green or brownish, usually lacking the greenish bands of the wingless form, and the honey-tubes are brown with rusty spots around the base. The species may be distinguished by the very short second fork of the median vein at the tip of the fore-wings.

Life History.—The eggs are found on the apple and pear, and the first two generations in the spring develop as do those of the

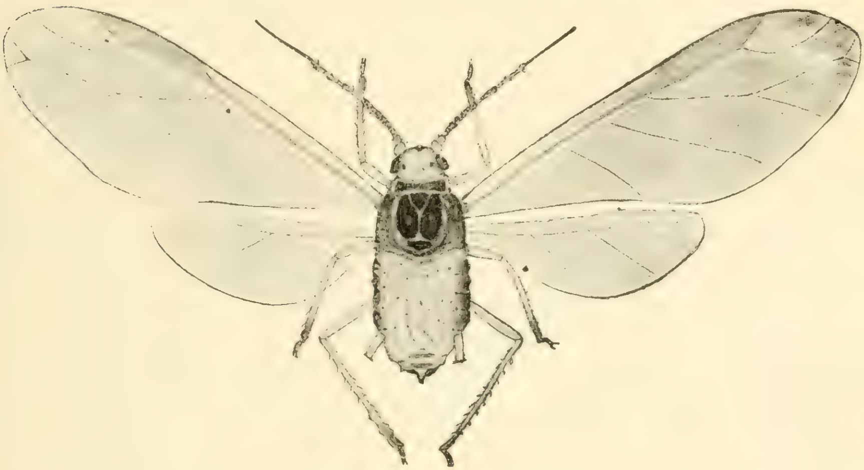


FIG. 458.—The European grain-aphis, migrating winged viviparous female of the second generation—greatly enlarged.

preceding species. All of the second, or sometimes the third, generation become winged and migrate to small grains and grasses, on which they feed during the summer. In the fall winged females return to the fruit trees and give birth to young, which develop into wingless females and winged males, which mate and produce the winter eggs. Pergande states that "the species is biennial and that the progeny of the spring migrants from the apple subsist almost exclusively upon various grains and grasses until the fall of the second year, when a generation of return migrants makes its appearance." This is certainly true in the South, where the aphides may be observed on grains throughout

the winter, but it may be questioned whether they usually survive the winter on grains or grasses in the North.

Professor F. M. Webster* has observed this species on wheat in Ohio, and states that in mild winters it remains on the wheat, going down on the stems to just below the surface of the soil or to the upper roots, as we have observed it in Texas. "Here they go on reproducing when the temperature is favorable," he says, "the adults being apterous so far as observed by me, until spring, when they ascend to the foliage, the adults after this being both winged and wingless. On the stems and roots below the surface of the ground they are of a greenish color, tinged with reddish-brown, especially posteriorly, the full-grown individuals often being wholly of a dark brown. It is during autumn that they do their greatest injury to the wheat by sucking the juices from the young plants, often, if on poor land and if in dry weather, checking their growth and causing the foliage to turn yellow." This species is seldom much in evidence on grains or grasses in midsummer and rarely becomes very injurious to them. On the apple it is abundant on the young foliage and particularly on the flower buds and blossoms, where it is much more common than the other species. It does not, however, curl the foliage nearly as severely as the other species, due to its earlier migration.

The Clover-aphis †

This species is more particularly a clover pest, but is mentioned because it oviposits on apple and pear and may be confused with other species in spring and fall. It has been observed in Colorado and has been injurious to clover in Iowa, but its further distribution is unknown. The wingless female of the first generation varies from a dark green streaked and mottled with red to a deep dark red, with honey-tubes very short and pale yellow throughout. The second generation are light green or yellowish-green and

* See Bulletin 51, Ohio Agr. Exp. Station, p. 111.

† *Aphis bakeri* Cowen. Family *Aphididæ*. See Gillette and Taylor, l.c.; C. P. Gillette, Journal Economic Ent., Vol. I, p. 364.

the summer generations on clover are pink or yellowish, with a large pale orange spot around the base of each honey-tube. Concerning this species Gillette and Taylor give the following: "The clover aphis, *A. bakeri*, infests the cultivated and sweet clovers and alfalfa throughout the warmer part of the year where, apparently, it never occurs in the oviparous form nor as eggs. In the fall a portion of the winged lice migrate to apple and pear trees, where eggs are deposited to live over winter and hatch into the red stem mothers the following spring," hatching a week or two before the apple-aphis. "The descendants of these stem females begin in the second generation to get wings and by the middle of June nearly all have left the trees and gone back to the clovers, though some remain on the apple all summer. In the fall, many of the lice continue upon the clovers, going down close to the ground as cold weather comes on, and if the winter is not very severe, many will survive and continue to live and increase upon these plants throughout the year. So far as our observations have gone this louse ranks next to the green apple-aphis (*Aphis pomi*) in numbers as a leaf-infesting species of the apple, . . . but we can hardly consider it a serious pest as yet in Colorado orchards." Evidently the life history closely parallels that of the previous species, *S. avenæ*.

Control.—Recent experiments have shown that lime-sulfur wash applied while the trees are dormant, as for the San José scale, will kill nearly all aphid eggs. Pure crude petroleum has also proven effective against the eggs in several experiments. Recently Professor Gillette has reported * experiments which indicate that tobacco extracts will destroy the eggs when used at various dilutions according to the strength of the extract, but though these preparations may be effective, further field experiments will be necessary to determine the exact dilution best for orchard use. Spraying for the aphides after they hatch should be done before they commence to curl the leaves, preferably just as the foliage is expanding, for after the leaves are curled it is impossible to reach them with the spray successfully. Kerosene emulsion

* C. P. Gillette, Journal of Economic Entomology, Vol. III, p. 207.

containing 7 per cent kerosene, whale-oil soap 1 pound to 5 or 6 gallons, dilute miscible oils, or tobacco extracts will destroy the aphides. The spray should be applied with some force, so as to hit all of the aphides and to penetrate the hairy terminals of the apple. Where trees are being sprayed with Bordeaux mixture, whale-oil soap or tobacco extracts may be added to it, to save separate spraying.

The Tent Caterpillar *

From the earliest times the webs of the tent caterpillar have adorned the neglected, wayside apple and cherry trees in all parts of the country east of the Rocky Mountains. On the Pacific Coast a nearly related species has very similar habits. The adult moths are common in July in the North or in May in the Gulf States. They are stout-bodied, of a reddish-brown color, with two nearly parallel white bands extending obliquely across the fore-wings. The females have a wing expanse of about $1\frac{1}{2}$ inches, while the males are smaller and may be distinguished by their feathery antennæ. The sexes soon mate and the females deposit their eggs about five or six weeks after apples blossom. The egg-mass is from one-half to three-quarters inch long and forms a grayish-brown, knot-like band around the twig on which it is laid, closely resembling the bark in color. Each mass contains about 200 eggs, placed on end, packed closely together and covered with a light-brown, frothy glue, which gives a tough, smooth, glistening surface to the whole mass. The little caterpillars hatch just as the leaf buds are expanding in the spring. Ofttimes they emerge before the leaf buds have expanded sufficiently to furnish any food, in which case they satisfy their hunger with the glutinous covering of the egg-mass, spinning a thin web over it. Soon they are able to bore into the buds and a web is commenced at the nearest crotch. Wild cherry and

* *Malacasoma americana* Fab. Family *Lasiocompidæ*. See A. L. Quaintance, Circular 98, Bureau of Entomology, U. S. Dept. Agr.; V. H. Lowe, Bulletin 152, N. Y. Agr. Exp. Sta.; E. P. Felt, 14th Report State Ent. N. Y., pp. 177–190.

Fig. 459

Fig. 460

Fig. 461

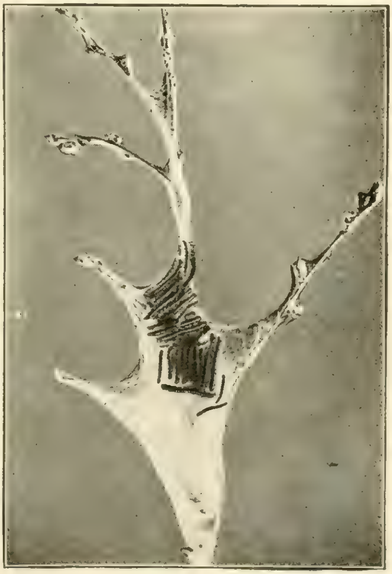


Fig. 462

The Tent Caterpillar.

Fig. 459.—Egg mass on twig—natural size.
Fig. 460.—Egg mass covered with web of newly-hatched caterpillars.
Fig. 461.—Newly-formed web.
Fig. 462.—Web bearing half-grown caterpillars—reduced in size.

apple are the favorite food-plants and are often stripped of their foliage year after year, but all of the common fruit trees are more or less frequented, and when very abundant the common shade trees are attacked and occasionally one is defoliated. The little caterpillars from one egg-mass co operate in spinning the tent which furnishes them shelter at night and during cold or wet weather. This is gradually enlarged with new layers of silk, the caterpillars living beneath the outer layers. The caterpillars are grown in five or six weeks, when they become exceedingly restless and wander away from the nest in search of suitable places for spinning their cocoons. The full-grown caterpillar is about 2 inches long, deep black in color, sparsely covered with yellowish hairs, with a white stripe down the middle of the back. On the side of each segment is an oval pale blue spot with a broader velvety black spot adjoining it in front, giving somewhat the effect of an eye-spot. Having found a suitable place under loose bark, in a fence, in the grass or rubbish beneath the tree, or in the shelter of some neighboring building, the caterpillar settles down and proceeds to encase itself in a thin cocoon of tough white silk, in which it transforms to the pupa. About three weeks later the adult moth emerges from the pupa to continue the life cycle, there being but one generation a year.

FIG. 463.—Tent caterpillars on web—one-half natural size. (Photo by Weed.)

The caterpillars are held in check by numerous parasitic insects, some 24 species having been found preying upon them by Mr. W. F. Fiske in New Hampshire,* as well as by predaceous soldier bugs (*Podisus* spp.) and many of our common birds. Large numbers of the caterpillars are also carried off by a bacterial disease. When nearly full grown the caterpillars become sick and sluggish, and soon become flaccid and the skin is easily ruptured, permitting the escape of the body fluids. Several

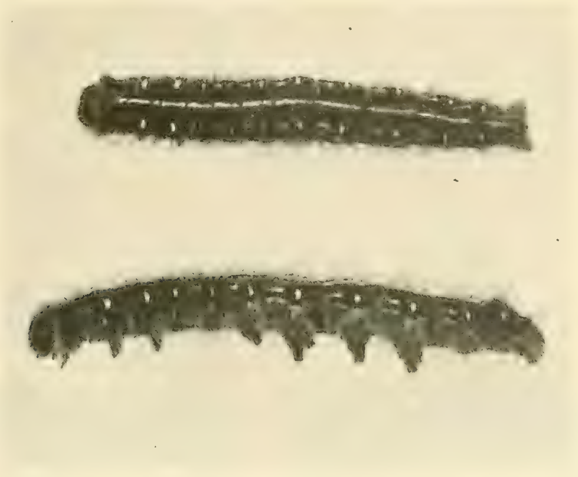


FIG. 464.—Tent caterpillars, back and side view—$1\frac{1}{4}$ times natural size.

species of little chalcis-flies are parasitic in the eggs and destroy a large proportion of them. Were it not for these natural enemies the tent caterpillar would become a much more serious pest.

Control.—The egg-masses may easily be detected and pruned off during the winter, and it would be well to leave them in a box covered with netting so that the parasites may escape. Neglected apple and wild-cherry trees should be destroyed, as they harbor this and other pests and are usually valueless. The caterpillars may be quickly destroyed by spraying with Paris green or arsenate of lead just after the foliage comes out, before the trees blossom.

* See W. F. Fiske, Tech. Bulletin 6, N. H. Agr. Exp. Sta.

FIG. 465.—The tent caterpillar moth. (After Lowe.)

FIG. 466.—Cocoons of the tent caterpillar, natural size. (After Lowe.)

FIG. 467.—Web of the tent caterpillar riddled by birds. (Photo by Weed.)

If there are but a few nests the caterpillars may be destroyed in them by spraying the nest on a cloudy or cool day with pure kerosene. Apply the spray with an extension rod and fine nozzle so that the nest will be thoroughly soaked, without spraying the surrounding foliage. Or the caterpillars may be destroyed by burning the nests with a torch while they are in them, or while young they may be swabbed out with a broom or brush and crushed.

The Yellow-necked Apple Caterpillar *

During late summer the tips of apple limbs are often found defoliated for a foot or two and if examined a mass of caterpillars will be found huddled together as if confessedly guilty. Usually these will prove to belong to this or the following species. The full-grown yellow-necked apple caterpillar is about 2 inches long, with a jet black head and the next segment, often called the neck, a bright orange yellow, from which the insect is named. Down the middle of the back runs a black stripe, and on either side of the body are three stripes of black alternating with four of yellow and the body is thinly clothed with long, soft white hairs.

FIG. 468.—Yellow-necked apple caterpillars assembled on apple twig in natural position—from life, much reduced.

* *Datana ministra* Drury. Family *Notodontidæ*. See A. S. Packard, Memoirs National Academy of Sciences, Vol. VII, p. 106; E. D. Sanderson, Bulletin 139, N. H. Agr. Exp. Sta., p. 213.

While young the caterpillars feed only on the under surfaces of the leaves, but as they become larger the whole leaf, except the stem, is devoured. They feed together in colonies, usually starting at the tip of a limb, where the eggs were laid, and stripping the foliage toward the base, and are often found clustered together in a solid mass. If the limb is jarred or a caterpillar touched, it at once assumes a position characteristic of this genus, throwing the head and tail in the air with a jerk and clinging to the limb by the abdominal prolegs, as shown in Fig. 468. The wings of the adult moth expand about two inches and are a reddish-brown color, while the head and thorax are chestnut brown. The fore-wings have three to five transverse lines, one or two spots, and the outer margin of a dark color, and the hind-wings are pale yellowish without markings.

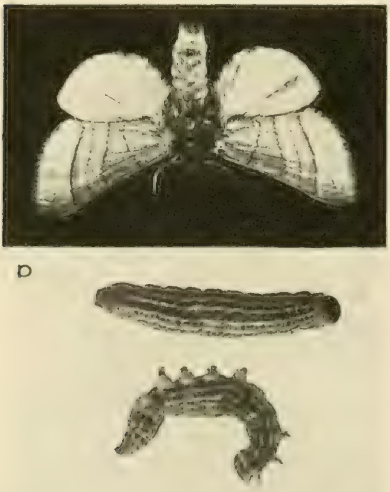


FIG. 469.—The yellow-necked apple caterpillar (*Datana ministra* Dru.): mature larvæ and moth natural size.

Life History. — The winter is passed in the pupal stage in the soil, from which the moths emerge from May to July. The round, white eggs are laid on the leaves in masses of 75 to 100, and hatch during mid-summer. The caterpillars feed during the late summer and become full grown in four or five weeks, when they enter the earth for from 2 to 4 inches and there transform to naked brown pupæ, without making any cocoons. There is but one generation in the Northern and Middle States.

The species occurs throughout the Northern and Middle States east of the Rocky mountains, and in the far South there seem to be no records of the species. Though most common on apple, it also feeds on pear, cherry, quince, and plum, and on hickory,

oak, walnut, chestnut and other shade and forest trees, sometimes defoliating them, as do other nearly related species.

Control.—As the work of these caterpillars is soon noticed, and as they habitually feed in colonies, it is an easy matter to hand pick and destroy them, or swab them off the limbs with a rag or waste saturated with kerosene, or where a colony is clustered at the tip of a limb, it may be cut off and crushed. If this and other caterpillars are abundant on the foliage in late summer, it will be well to spray with arsenate of lead 3 pounds to the barrel while the caterpillars are small, which will be about six to eight weeks after the apple blossoms fall.

The Red-humped Apple Caterpillar *

This species is often associated with the preceding in very similar injury, and has practically the same habits. The name is given on account of the prominent hump on the fourth segment of the larva, which with the head is a bright coral red. The mature caterpillar is striped with yellowish-white, alternating with dark brown or blackish lines, and a double row of black spines extends along the back. The fore-wings of the moth expand about $1\frac{1}{4}$ inches, are dark brown on the inner and grayish on the outer margin; they have a dark-brown dot near the middle, a spot near each angle, and several longitudinal streaks of the same color along the posterior margin. The hind-

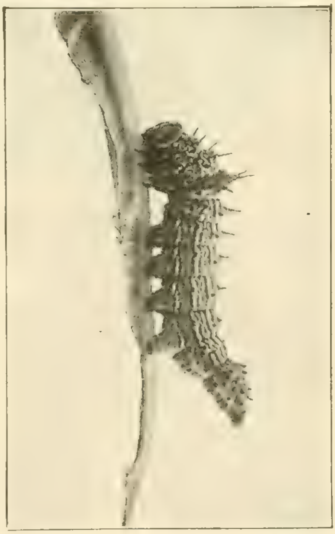


Fig. 470.—The red-humped apple caterpillar (*Schizura concinna* S. & A.)—slightly enlarged.

* *Schizura concinna* Smith and Abbott. Family *Notodontidæ*. See A. S. Packard, Memoirs National Academy of Sciences, Vol. VII, p. 212; E. D. Sanderson, Bulletin 139, N. H. Agr. Exp. Sta., p. 216.

wings of the male are brownish and of the female dusky brown, the body is light brown with the thorax of a darker shade.

This species occurs throughout the United States and feeds on apple, plum, rose, thorn, cherry, blackberry, willow, oak, hickory, and other trees and shrubs. The caterpillars become full grown in late summer or early fall and then spin loose silken cocoons to which are attached bits of earth and rubbish, so that they closely resemble their surroundings as they lie on the ground beneath rubbish, or just under the surface of the soil. After some time the larvæ transform to pupæ, in which stage the winter is passed. Otherwise the life history is practically the same as the preceding species, except that there is some evidence of there being two generations in the South. The larvæ of this species are very frequently parasitized by little ichneumon-flies * which destroy whole colonies of them while still young, the inflated skins being found on the under side of a leaf, often perforated by the round exit holes of the parasites.

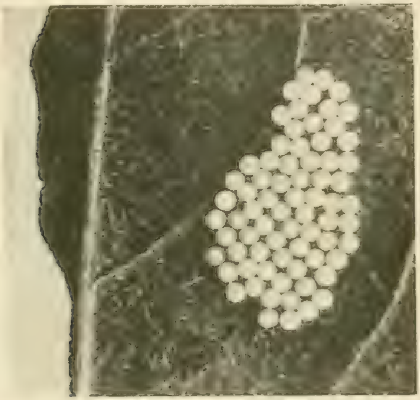


Fig. 471.—Eggs of the red-humped apple caterpillar—enlarged.

Control.—Same as for the preceding species.

The Apple Leaf-miner †

This is the most common leaf-miner of the apple and makes small brown trumpet-shaped blotches under the upper surfaces

* *Limneria fugitiva* Say, and *L. ademasia* Ashm. Family *Ichneumonidæ*.

† *Tischeria malifoliella* Clemens. Family *Tineidæ*. See A. L. Quaintance, Bulletin 68, Part III, Bureau of Entomology, U. S. Dept. Agr.; C. D. Jarvis, Bulletin 45, Storrs (Conn.) Agr. Exp. Sta.; C. O. Houghton, Bulletin 87, Del. Agr. Exp. Sta.

of the leaves. It has not been regarded as a serious pest until recently, but during the last few years it has become so abundant as to do serious injury to apple foliage in New England and the Middle Atlantic States, in some instances largely defoliating the trees. It is a native insect which is generally distributed east of the Rocky Mountains.

The adult is a little moth whose wings expand about one-third inch and are broadly fringed as shown in the figure. Clemens describes it as follows: "Head and antennæ shining dark brown, face ochreous. Fore-wings uniform, shining dark brown with a purplish tinge, slightly dusted with pale ochreous; cilia of the

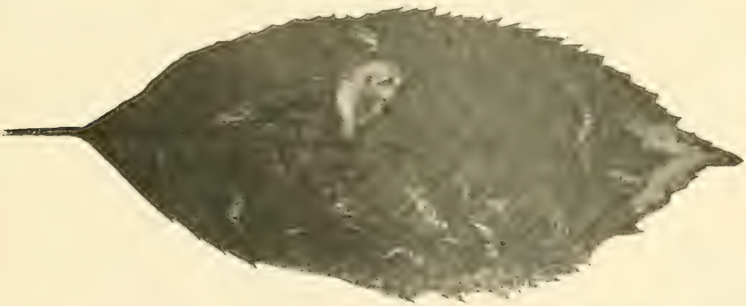


Fig. 472.—Trumpet-shaped mine of the apple leaf-miner (*Tischeria malifoliella* Clem.). (Photo by Quaintance, U. S. Dept. Agr.)

general hue. Hind-wings dark gray; cilia with a rufous tinge." The full-grown larva is one-third inch long, somewhat flattened, and tapers from the broad thorax to the last segment. It is light green except the back of the prothorax and the anal segment, which are brown.

Life History.—The moths emerge in late April in Delaware and in May in Connecticut. The small greenish-yellow, blister-like eggs are elliptical in outline, about one-fiftieth inch long, and are attached closely to the surface of the leaf. They hatch in from eight to ten days and the young larvæ mine directly into the leaf from the under side of the eggs. The larvæ become full grown in about three weeks and pupate in their mines, the pupal stage lasting eight to ten days. Thus the whole life cycle requires

but about thirty-three days in the District of Columbia, where there are four generations a year, and about six weeks in Connecticut, where there are but two generations. The larvæ of the last generation line their mines with silk and in them pass the winter in the fallen leaves, transforming to pupæ the next spring.

Control.—As the larvæ pass the winter in the fallen leaves, the insect may be entirely controlled by plowing under the leaves in late fall or early spring or by raking them up and burning them. When the larvæ become so abundant as to threaten serious injury in summer they may be killed in their mines by spraying the foliage with 10 to 15 per cent kerosene emulsion, but this is not satisfactory in the early fall.

The Pistol Case-bearer * and the Cigar Case-bearer †

These interesting little case-bearers have long been known as apple insects, but only in comparatively recent years have they

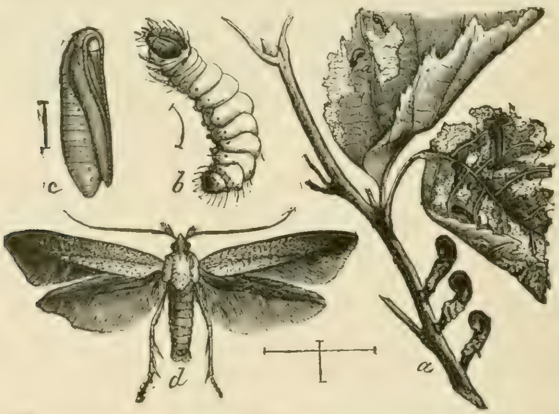


FIG. 473.—The pistol case-bearer (*Coleophora malivorella* Riley): *a*, apple twig showing larval cases and work on leaves; *b*, larva; *c*, pupa; *d*, moth; *b*, *c*, *d*, enlarged. (After Riley.)

done sufficient injury to attract attention. Both species have done serious damage in New York by boring into the young buds

* *Coleophora malivorella* Riley. Family *Elachistidæ*. See V. H. Lowe. Bulletin 122, N. Y. Agr. Exp. Sta.

† *Coleophora fletcherella* Fernald. Family *Elachistidæ*. See M. V. Slingerland, Bulletin 93, Cornell Univ. Agr. Exp. Sta.; A. G. Hammar, Bulletin 80, Part II, Bureau of Entomology, U. S. Dept. Agr.

and blossoms, and eating off the surface of the leaves, so that in some cases orchards have been practically defoliated. The pistol case-bearer seems to be generally distributed over the eastern United States and southern Canada, while the cigar case-bearer is known to occur in southern Canada from Nova Scotia to British Columbia, in New York, Michigan, Kansas and New Mexico. As both insects are readily carried on nursery stock they are doubtless much more widely distributed than the records indicate.

Life History.—The life histories of both species are very similar

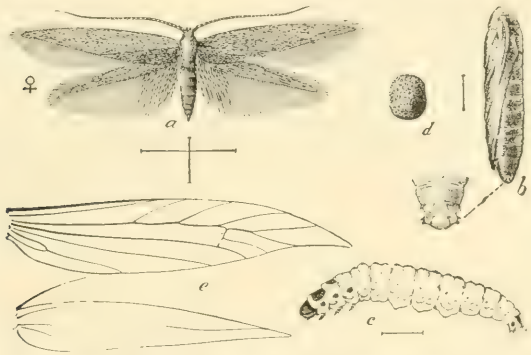


FIG. 474.—The cigar case-bearer (*Coleophora fletcherella* Fernald): *a*, adult female; *b*, side view of pupa and upper view of cremaster of same; *c*, larva; *d*, egg; *e*, venation of wings—much enlarged. (After Hammar, U. S. Dept. Agr.)

and have been most interestingly described in detail by the authors cited. The young caterpillars hibernate in their little cases, which are attached to the twigs usually near or upon the buds.

Those of the pistol case-bearer are about one-eighth inch long and resemble the bark in color. A short time before the leaf-buds burst in the spring, the larvæ become active and attack the growing buds, gnawing through the outer cover to feed on the tender tissues beneath. Later they feed on the young leaves, making small holes through the surface and feeding on the soft tissue within in much the same manner as a true leaf-

miner. In feeding they do not leave the case, but reach out as far as possible from it. As they grow they enlarge their cases, which finally assume the shape characteristic of the species.

Those of the cigar case-bearer are straight and resemble a miniature cigar, being of a brown color and composed of bits of leaf bound together with silk. The cases of the pistol case-bearer resemble an old-fashioned pistol in shape, the butt being at the upper end, and are blackish, being composed of excrement and silk. As the caterpillars become larger they devour the entire leaf, except the midrib and large veins, and also attack the flower buds, flowers and fruit. The larvæ of the cigar case-bearer become full grown about the middle of June in New York, when they migrate to the twigs, where they attach their cases firmly to the bark and, turning around so that their heads are outward, transform to pupæ. The pupal stage lasts ten or twelve days, most of the moths emerging in early July. The pistol case-bearers become full grown and transform about a month earlier. The adults of both species are little grayish moths with wings expanding about one-half inch, and broadly fringed with long hairs. The eggs of both species are laid singly on the under sides of the leaves and hatch in ten days to two weeks. The young caterpillars which hatch from them feed within the leaf for a short time as leaf-miners, before they make their little cases and migrate to the twigs, where they remain until spring.

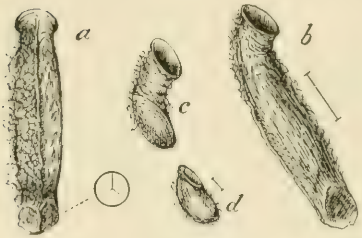


FIG. 475.—The cases of the cigar case-bearer: *a*, upper view of the cigar-shaped case; showing the smooth and the hairy sides and the three-lobed hind opening; *b*, side view of same; *c*, the case as it appears in the spring with the tube-like addition; *d*, the fall and winter case—much enlarged. (After Hammar, U. S. Dept. Agr.)

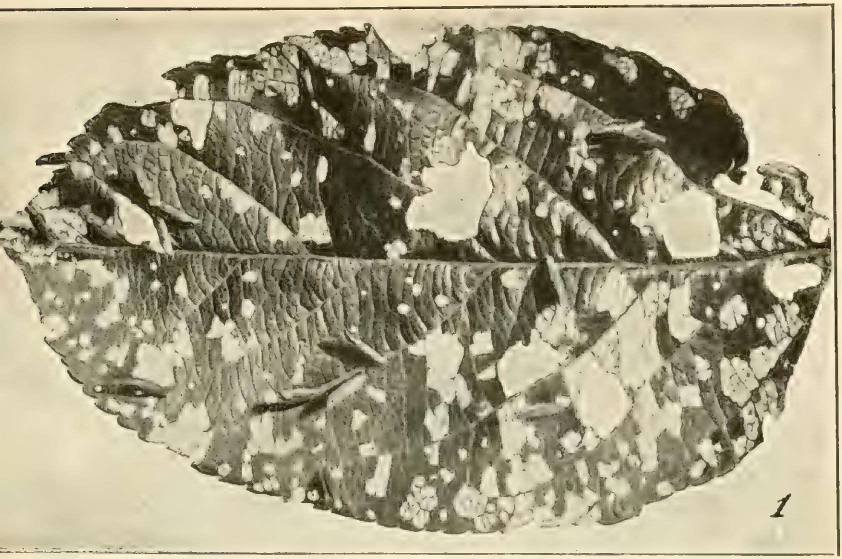


FIG. 476.—Apple leaf with cigar case-bearers at work—natural size. (After Hammar, U. S. Dept. Agr.)

Control.—Spraying with Paris green or arsenate of lead just before the leaf buds open and again as soon as the foliage is out, will destroy the little caterpillars.

The Bud Moth *

This is a European species which was first noted in this country in 1841, and has since spread throughout the Northern and Middle States east of the Rocky Mountains and to Oregon and Idaho. The larvæ feed on all of the common deciduous fruit trees, and blackberry, but are most commonly injurious to apple. The adult moth is a dark ash gray with broad yellowish bands across the fore-wings, which expand about five-eighths inch. The full-grown caterpillar is one-half inch long, of a light chestnut-

* *Tmetocera ocellana* Schiff. Family *Tortricidæ*. See M. V. Slingerland, Bulletin 107, Cornell Univ. Agr. Exp. Sta.; W. E. Britton, 9th Report, State Entomologist of Connecticut, p. 353.

brown color, with the head, legs and thoracic shield dark brown or black, smooth and shiny.

Life History.—The larvæ hibernate in small, oval, silken cases attached to the bark of a twig. About the time the buds begin to swell in the spring, the caterpillars bore into them, thus early protecting themselves from insecticides. As the young leaves and flowers unfold, the caterpillars form nests for themselves by tying the leaves together, and destroy the young foliage and flower buds, but do not leave the nests in feeding. In New York, they become full grown during June, and transform to pupæ in the silk-lined nests. About ten days later the moths emerge and lay the eggs singly or in small clusters on the under surface of the leaves.

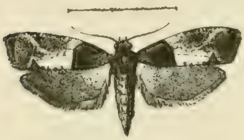


Fig. 477.—The bud moth (*Tmetocera ocellana* Schiff.)—twice natural size. (After W. E. Britton.)

Fig. 478.—Young apple leaves infested by the bud moth larva. (After W. E. Britton.)

The egg is disk-like, much flattened, usually oval in shape, and transparent, resembling a minute drop of water. The eggs soon hatch and the young caterpillars feed on the under

sides of the leaves, protecting themselves by a thin silken web. In the fall they migrate to the twigs and form the small silken cases in which they pass the winter.

Control.—Dr. Britton reports that the caterpillars may be

Fig. 479.—Apple leaf injured by the bud moth caterpillar—natural size. (After W. E. Britton.)

effectively destroyed by spraying with arsenate of lead 1 pound to 10 gallons, which should be applied just as the buds are bursting and again before the trees blossom.

The Codling Moth *

The common apple worm, the larva of the codling moth, is probably the best known and most generally destructive of all the apple insects. It is an old European insect and has been distributed to almost all parts of the world where apples are

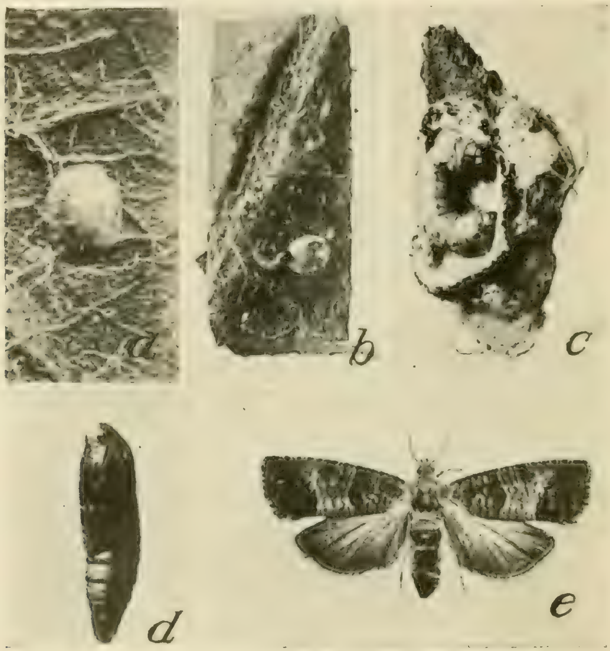


Fig. 480.—The codling moth (*Cydia pomonella* Linn.): *a*, egg—greatly enlarged; *b*, young larva hatching from egg; *c*, larva in winter cocoon on inside of a bit of bark; *d*, pupa—original; *e*, moth—after Slingerland—all much enlarged.

grown. The "wormy" apple is so well known that the work of the larva needs no description, but the aggregate loss which it occasions is not always appreciated, as most of the injured

* *Cydia pomonella* Linn. Family *Tortricidæ*. See A. L. Quaintance, Yearbook U. S. Dept. Agr., 1907, p. 435; E. L. Jenne, Bulletin 80, Part I, Bureau of Entomology, U. S. Dept. Agr.; C. B. Simpson, Bulletin 41, n. s., Div. Ent., U. S. Dept. Agr.; E. D. Sanderson, Bulletin 143, N. H. Agr. Exp. Sta.; and bulletins of the State Agricultural Experiment Stations.

fruit drops and no account is kept of the windfalls, and if the picked fruit is not seriously infested the grower does not notice that he has lost a large part of the crop, though where the pest is abundant so much of the fruit is injured that but little remains to be picked on unsprayed trees. In 1907 Professor Quaintance estimated the annual loss due to this insect in the United States at about $12,000,000.

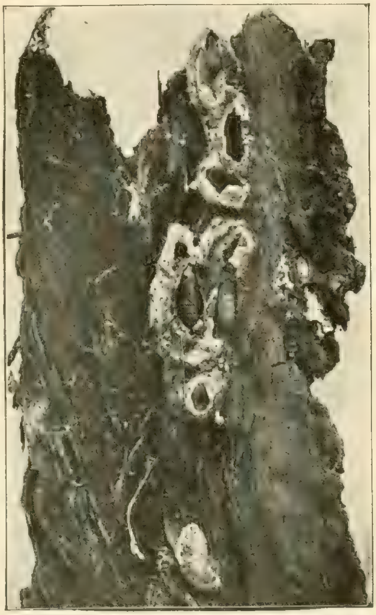


Fig. 481.—Cocoons of codling moth as found attached to a piece of loose bark—natural size. (After Slingerland.)

The moths fly at dusk and are rarely seen, as during the day they rest on the bark which they closely resemble in color. The wings expand about three-quarters inch and have somewhat the appearance of grayish-brown watered silk, but when more closely examined are seen to be crossed by numerous lines of gray and brown scales. Near the hind angle of each front wing is a large dark brown spot marked with streaks of brown or gold. The hind-wings are of a lighter grayish-brown color, darker toward the outer margin.

Life History.—The winter is passed by the full-grown larvæ in their small white cocoons beneath or in crevices of the bark. About the time the apples blossom the larvæ transform to small brown pupæ, from which the moths emerge in two to three weeks. If the evenings be warm the females commence to deposit their eggs within a few days, laying most of them on the foliage. A female lays from 60 to 75 eggs, and though most of them are placed on leaves near the young fruit, ofttimes they are deposited on limbs or trees with no fruit. The individual egg looks much

like a small white blister about the size of a pinhead. It is at first quite transparent, but later a brownish or blackish streak is seen, showing the little caterpillar forming within. The eggs hatch in from five to ten days, depending upon the season and temperature, most of them hatching about three or four weeks after the blossoms fall.

The young apple worm is at first only about one-sixteenth inch long, of a whitish color, with a shining black head, and with distinct blackish tubercles over the body, which become quite indistinct in later life. Upon hatching the young larva usually feeds a little on the tender parts of the leaves before it crawls to the nearest apple, which is probably 8 or 10

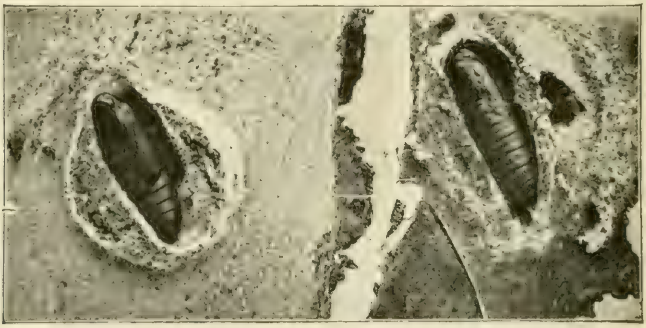


FIG. 482.—Pupæ of codling moth in cocoons—enlarged. (After Slingerland.)

inches distant. About two-thirds of the larvæ enter the apples through the blossom end and feed a little within the calyx before they bore inward to the core. The others enter at the stem end or at the side, where a leaf may touch the apple. The seeds of the apple seem to be most relished, for the larva soon hollows out each of them as well as the surrounding core, its work being indicated by the well-known excreta thrown out from the calyx, showing the "worminess" of the apple. The larva becomes full grown in from three to four weeks and eats its way out through the side of the apple, leaving a round exit hole, and seeks a place to form its cocoon. The full-grown caterpillar is about three-quarters inch long, whitish or pinkish in color, with a brown head

and faint tubercles over the body, and with three pairs of thoracic legs and five pairs of abdominal prolegs. The cocoons are found mostly on the trunks of the trees, as in winter. The pupal stage of the first summer generation lasts ten to twelve days, and the moths emerge about eight weeks after the eggs were laid.

FIG. 483.—Pupa skin of codling moth remaining attached to cocoon—enlarged.

In northern New England but 2 or 3 per cent of the larvæ pupate, the majority hibernating over winter, so that there is but a small second generation. Further south a large number transform and in the Middle States there are two full generations. In the far South, as in Georgia, Arkansas and New Mexico, there are three generations In any event the larvæ leave the apples in the fall and hibernate in their cocoons, those but partly grown usually dying before spring. The life cycle of the second and third generations are essentially the same as that of the first, except that a large proportion of the eggs are laid on the fruit and more of the larvæ enter the apples through the sides or stem end. The work of the larvæ of the later broods is also somewhat different, as much of it consists of eating around the blossom end or on the face of the apple, eating out small holes or tunneling under the

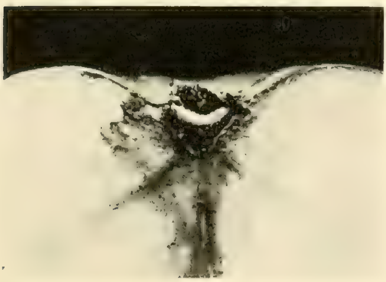


FIG. 484.—Young larva of codling moth in calyx cavity of apple—enlarged.

skin, as shown in Fig. 489. When two or three generations occur, the injury by them often becoms very severe if the first generation has not been largely destroyed by thorough spraying. Very similar injury is done by the larvæ of the lesser apple worm,* which is very difficult to distinguish, but fortunately the same treatment will control both pests.

FIG. 485.—Larva of the codling moth only a few days old, showing tubercles — much enlarged. (After Slingerland.)

Control.—Scraping the loose bark from the trees and keeping the bark smooth removes the favorable conditions for the hibernation of the larvæ. A large proportion of the hibernating larvæ are destroyed by woodpeckers and nuthatches during the winter and they should be attracted to the orchards by hanging up bones and suet. Picking up the fallen apples and destroying them before the larvæ have left them to form their cocoons will do much to mitigate the numbers and will aid in the control of other insects. Cellars and storage houses where apples are kept over winter should be screened to prevent the exit of the moths in the spring. The principal method of control, however, is in spraying with arsenicals, which, when properly done, will destroy practically all of the larvæ. Although Paris green and arsenite of lime (p. 43) have long been used for this purpose, arsenate of lead is now preferred on account of its superior adhesive qualities and because there is less danger of burning the foliage with it. Where Bordeaux mixture is sprayed for fungous diseases at the same time Paris green may be applied with it and the Bordeaux

* *Enarmonia prunivora* Walsh. Family *Tortricidæ*. See A. L. Quaintance. Bulletin 68, Part V, Bureau of Entomology, U. S. Dept. Agr.; Foster and Jones, Bulletin 80, Part III, *ibid.*

will cause it to adhere as well as arsenate of lead and there will be little danger of burning with a good quality of Paris green. One-third pound per barrel of Paris green, 2 or 3 pounds of arsenate of lead, or 1 quart of stock solution of arsenite of lime are the proper strengths for general use. The first spraying for the codling moth should be given just after the blossoms have fallen and before the sepals of the calyx close, the object being to place the poison in the calyx cavity so that the little larva will be poisoned when it enters and feeds in the calyx a few weeks later. In general this

FIG. 486.—Full grown larva of the codling moth—enlarged about three times. (After Slingerland.)

spraying should be given within a week or ten days after two-thirds of the petals have dropped, but the time will depend upon the variety and the season.

In the West great emphasis has recently been placed upon using a coarse spray with a high pressure, 100 to 250 pounds, which will drive the spray through the bases of the stamens into the lower calyx cavity, and though excellent result are undoubtedly secured in this way, experiments in the East indicate that a mist spray is equally effective if thoroughly applied, whether the lower calyx cavity is reached or not. There is no question, however, of the importance of maintaining

a good pressure, of at least 100 pounds, so that the spray may be forced through the foliage; for the blossoms point in all directions, and the spray must be forced through the tree to reach those pointing inward on the opposite side. To do thorough work the man spraying should stand on a tower which will place him level with the middle of the tree, so that with an extension rod all parts may be readily reached. An angle on the end of the rod which will

Fig. 487.—Young apples in right condition to spray for the codling moth and with calyx sepals closed too far for effective spraying. (After Quaintance, U. S. Dept. Agr.)

turn the nozzle at 35 or 45 degrees will greatly aid in reaching all parts of the tree.

The second spraying should be applied three or four weeks after the blossoms fall, just as the eggs are hatching At this time the object should be to cover the foliage thoroughly, so that the young larvæ may be killed while they feed on the foliage. Consequently both the upper and under surfaces of the leaves should be coated. If the first spraying has been well done, the second will often be unnecessary where there is but a partial second brood or where the pest is well under control, but as it is often necessary to spray for the fungous diseases

at this time it is well to add the arsenical, which but slightly increases the cost. Where there is a full second generation, as in most of the Middle and Pacific States, a third application as

FIG. 488.—Work of the first generation of codling moth larvæ.

the second generation of larvæ are hatching, will be found advisable about nine or ten weeks after the petals fall, and a fourth two or three weeks later may be necessary. With thorough spray-

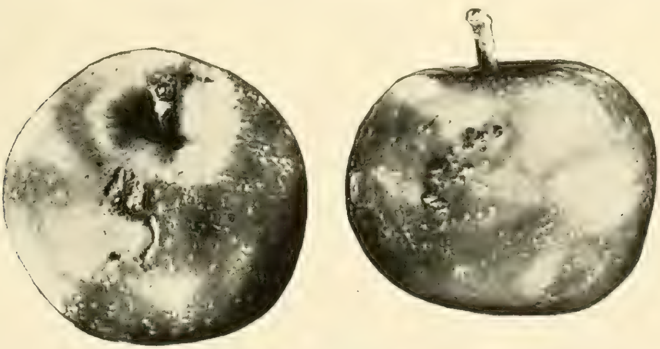


FIG. 489.—Work of the second generation of codling moth larvæ.

ing not over 1 or 2 per cent of the picked fruit should be wormy, as most of the wormy fruit will drop early in the season.

In mountainous districts, or where it is difficult to secure water, dusting the trees with Paris green blown by a dusting machine has been quite extensively practiced. Although this treatment

largely reduces the injury, careful experiments have shown that it is much less effective than liquid spraying, and as it is not satisfactory for the control of fungous diseases, the liquid spraying is to be preferred where feasible.

The Apple-maggot or "Railroad Worm" *

The apple-maggot has long been known as the worst pest of summer and fall apples in the New England States, and has extended its injuries to eastern New York and southeastern Canada. It has been recorded from Michigan, Wisconsin, Illinois, Minnesota, New Jersey, and Pennsylvania, but seems to be only occasionally injurious there, though it has been reared from haws in Illinois and Wisconsin, which would indicate that the insect is native in those States. Evidently it is widely distributed throughout the northeastern United States, but for some reason is most injurious in New England. The fruit is injured by the small white maggots, which burrow through the flesh, leaving discolored streaks through it, often becoming so numerous as to entirely honeycomb the pulp which breaks down into a yellowish mass merely held together by the skin. An apple quite fair exteriorly will often be found to be almost completely "railroaded" by the maggots, although brown, slightly sunken streaks in the skin usually indicate their presence. Sweet and subacid varieties of summer and early fall apples are worst injured, but where the pest develops unchecked, winter sorts, such as the Baldwin and particularly the Northern Spy, are often seriously injured.

The parent of the maggot is a little fly slightly smaller than the house-fly, of a blackish color, with yellowish head and legs, greenish eyes, and three or four white bands across the abdomen. The wings are marked by four black bands, as shown in Fig. 490, which distinguish it from similar flies found on apples.

* *Rhagoletis pomonella* Walsh. Family *Trypetidæ*. See A. L. Quaintance, Circular 101, Bureau of Entomology, U. S. Dept. Agr.; F. L. Harvey, Report Maine Agr. Exp. Sta., 1889, p. 190; W. C. O'Kane, Journal of Economic Entomology, IV, 173.

Life History.—The flies emerge during July in New England and live for several weeks. The females at once commence depositing their eggs in the early varieties of apples. The eggs are laid just under the skin in a vertical position, on the cheek of the apple. The egg is elliptical, about one-thirtieth inch long, and yellowish in color. A female will lay 300 to 400 eggs, 12 or 15 often being placed in a single apple. The eggs hatch in four or five days and the little maggots at once burrow into the pulp. By means of a vertical motion of the head they rasp the pulp with the small, black hook-like mouth parts, and in less than

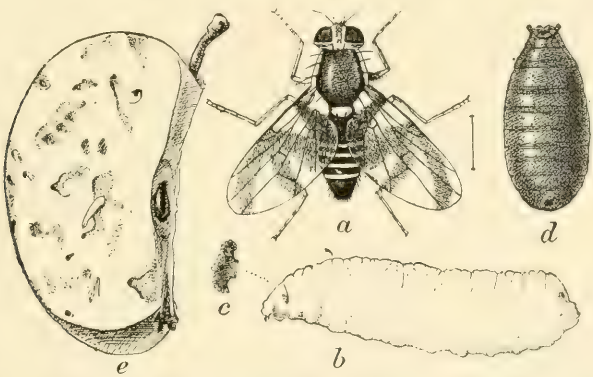


FIG. 490.—The apple-maggot (*Rhagoletis pomonella* Walsh): *a*, adult; *b*, larva or maggot; *c*, funnel of spiracle on head; *d*, puparium; *e*, portion of apple showing injury by maggots; *a*, *b*, *d*—enlarged; *e*—reduced. (After Quaintance, U. S. Dept. Agr.)

a minute can tunnel their own length. They become full grown in four to six weeks during the summer, but if only partly grown when winter sets in, many of them seem to hibernate until spring. The mature maggot is about one-third inch long, yellowish-white, footless, much like similar maggots, and distinguishable by the microscopic characters of the spiracles of the first and last segments. The mature maggot goes just beneath the surface of the ground, where its skin hardens to a puparium in which the pupa is formed, in which stage the winter is passed. In barrels or storage places the maggots pupate beneath the apples, and occasionally a puparium is found in the burrow of the maggot

within an apple. Most of the puparia are within 1 or 2 inches of the surface. There is but one generation a year.

Control.—As most of the affected fruit drops to the ground, during summer it should be picked up twice a week and destroyed before the maggots have left to it pupate. Where this is carefully done injury by the pest is greatly reduced. Particular attention should be given to the destruction of infested summer apples. Hogs pastured in the orchard will do this work admirably, and where there are but a few trees on bare or cultivated ground chickens will destroy the larvæ. Plowing the orchard deeply as early as feasible in spring and keeping it well cultivated in early summer will bury the puparia so as to greatly lessen injury, which is always worse in uncultivated sod orchards. As yet no method of spraying has been used which shows any effect on this pest, as the maggots inside the apple cannot be reached by a spray, but experiments are now being made in New Hampshire which may show a method of killing the adult flies, as has been done with a similar pest in the orchards in South Africa.

The Apple Curculio *

The apple curculio has been commonly confused with the plum curculio (p. 576), but is by no means as common or injurious, and

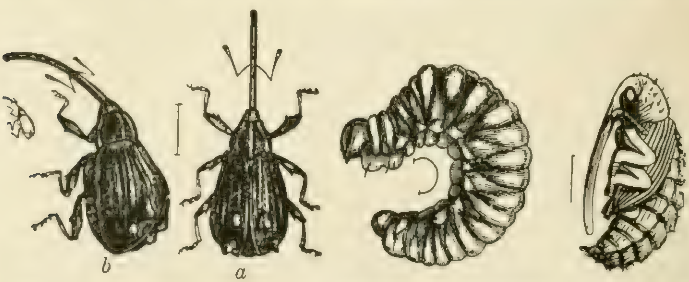


FIG. 491. The apple curculio (*Anthonomus quadrigibbus* Say): *a*, *b*, adult beetles; *c*, larva; *d*, pupa—all enlarged. (After Riley.)

is quite distinct in both appearance and habits. The adult beetle is about the same size as the plum curculio, but more reddish-

* *Anthonomus quadrigibbus* Say. Family *Curculionidæ*. See C. S. Crandall, Bulletin 98, Ill. Agr. Exp. Sta., p. 514; F. E. Brooks, Bulletin 126, W. Va. Agr. Exp. Sta., p. 113.

brown in color, the abdomen is more robust, and the wing-covers bear four prominent humps, the anterior being much larger than those on the plum curculio. The snout of the apple curculio is as long as the rest of the body and is held straight forward from the head, instead of hanging down as does the snout of the plum curculio. The work of the apple curculio is also different in that after laying the egg in a small cavity in the fruit, no crescent-shaped mark is made around it. The apple curculio is a native species which breeds in wild haw, wild crab, and wild cherry, and has been reared in plum, quince and pear. "It has been reported from Connecticut and Ontario south to North Carolina and westward as far as New Mexico. It seems to have been more troublesome in Missouri, Illinois and other mid-western States than elsewhere," but has never done anything like the injury due to the plum curculio and can hardly be regarded as a serious pest.

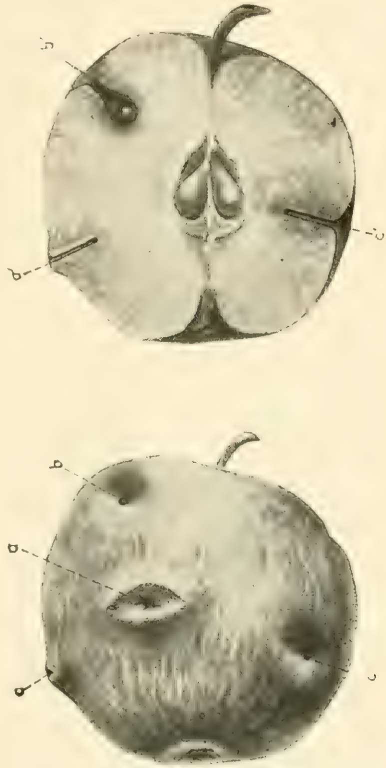


FIG. 492.—Work of the apple curculio; *a*, *a′*, *c*, *c′*, feeding punctures from the surface and in section; *b*, *b′*, egg punctures from the surface and in section. (After C. S. Crandall.)

Life History. The beetles commence laying eggs in the fruit soon after the blossoms drop and continue for a period of sixty days, an individual female laying about 65 eggs. The eggs hatch in about five days and the larvæ feed on the flesh of the apple for about twenty days, when they transform to pupæ within the fruit. A week later the beetles emerge, but feed very little during

the late summer before they enter hibernation for the winter, most of them leaving the trees by the latter part of August.

The larva is a footless, whitish grub a half inch long when full grown with a hump-backed appearance due to the enlargement of the anterior abdominal segments, which prevents the larva from straightening out. The beetles injure the fruit by puncturing it for feeding and for the deposition of eggs, causing it to become dimpled and gnarled as does the plum curculio, and the larvæ feed within the fruit, mining the flesh, in which they undergo their complete development.

Control.—Thickets of wild crab or hawthorn trees should be destroyed wherever near an orchard, for the beetles will breed in their fruit and then migrate to the orchard. Jarring as for the plum curculio may be practiced on young trees, and spraying as for that species will doubtless largely reduce the injury. Usually this insect is not sufficiently injurious to warrant special treatment where its native food-plants are not overabundant near the orchard.

The Pear Leaf Blister-mite *

The pear leaf blister-mite has long been known as a pest of pear foliage wherever the pear is grown, and has similarly affected apple foliage in Europe, but only in recent years has it become a serious pest of apple foliage in New York, New England, Ontario and Pennsylvania. Just why it should suddenly become an apple pest after having occurred in this country for years without noticeably injuring it is a mystery, though dry seasons may possibly be accountable for it.

The work of the mites is recognized by reddish blisters forming on the young foliage, which later turn blackish and have a corky texture. Badly affected leaves drop, so that a tree is often largely defoliated, and where the mites are abundant they attack the young fruit.

* *Eriophyes pyri* Pgst. Class *Arachnida.* Order *Acarina.* Family *Eriophyidæ*, with which are associated several nearly related species with similar habits. See Parrott, Hodgkiss and Schoene, Bulletins 283 and 306, N. Y. Agr. Exp. Sta.

The mites are not true insects, as they belong to the same class as the spiders, scorpions, and ticks. One of the more common larger mites is the red spider of greenhouses, which affects flowering plants, vegetable crops, and fruits of all sorts. These little blister-mites are of microscopic size, only 1/100 to 1/200 inch in length, so that they can only be seen with a lens, and must be examined with a compound microscope to distinguish the species. One is shown much magnified in Fig. 493. They are elongate, with two pairs of legs, and slender abdomens, composed of 50 to 80 small rings, frequently marked with rows of small tubercles and ornamented with a few hairs and bristles.

Life History.—The mites spend the winter in the buds, and

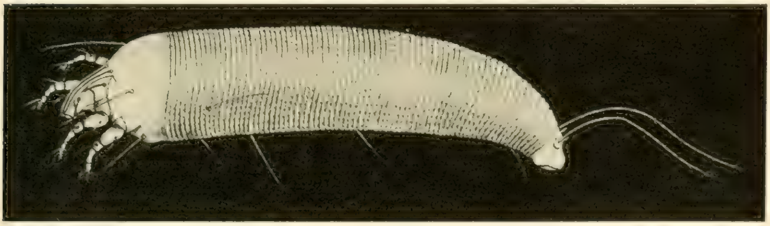


FIG. 493.—The pear leaf blister-mite (*Eriophyes pyri* Pgst.): highly magnified. (After Parrott.)

as warm weather approaches in the spring they become active and move toward the base of the growing bud scales and feed there. As the young leaves unfold the mites migrate to them. They burrow through the surface of the leaf and feed upon the succulent tissue within, setting up an irritation which soon results in reddish spots on the surface. Within these mines the eggs are laid, as many as 14 having been found in a single blister. The young hatch in about a week and burrow around in all directions, feeding on the tissues and juices. When full grown they leave the gall through small openings in the under surface and start new colonies which produce similar galls. They continue to reproduce and migrate throughout the summer, and under favorable conditions become numerous enough to completely

infest the new leaves as they appear. In the fall they leave the leaves to hibernate in the buds as already described.

On pear the blisters are at first greenish pimples, which become reddish and later brilliant red blisters, and finally they become brown or black and the tissue corky. When numerous the

FIG. 494.—Old leaf cluster with galls of pear leaf blister-mite on apple fruit and leaves. (After Parrott, Hodgkiss and Schoene.)

galls coalesce, forming dark brown patches over the leaf, which often break open, particularly along the edges of the leaves. On the blossom ends of the fruit and on the stems they produce light-colored pimples, which do not seem to injure the fruit. On apple the blisters are less brilliantly colored than on pear,

and become a light brown or dark green color on the upper leaf surface and uniformly brown beneath, looking something like the work of the apple rust. The young fruit is sometimes attacked, on which small green pimples, which later make blister-like spots or pock marks, are made toward the blossom ends, but which do not seem to cause much damage.

Control.—The mites may be controlled by spraying with 10 per cent kerosene emulsion, miscible oils, or lime-sulfur wash used the same as for the San José scale. Spraying should be done in October or November as soon as possible after a majority of the leaves have fallen, as many of the mites are still in the pubescence of the young wood, where they are more easily destroyed than when under the bud scales. In spring spray just as the buds begin to break and show the tips of the young leaves; spraying later than this will injure the foliage, and earlier spraying is not as effective. By using lime-sulfur in the spring, the usual treatment with Bordeaux mixture for diseases at that time is unnecessary. Where infestation is serious both fall and spring sprayings should be given; otherwise the fall spraying is the better. The buds and new growth should be thoroughly drenched, while the rough bark of the trunk and old limbs may be neglected as far as the mites are concerned. Where pear trees are but slightly infested, the spread of the pest may often be prevented by simply pruning out and burning the infested twigs upon the first appearance of injury.

The Pear Psylla *

Where the pear psylla is abundant, pear growers have come to fear it next to the San José scale, and until recently owners in eastern New York became so discouraged in their attempt to control it that orchards were cut down. It is an old European pest and was first noted in Connecticut in 1832, since when it has spread southward to Maryland and Virginia and westward to

* *Psylla pyricola* Foerst. Family *Psyllidæ*. See M. V. Slingerland, Bulletins 44 and 108, Cornell Univ. Agr. Exp. Sta.; C. L. Marlatt, Circular 7, Div. Ent., U. S. Dept. Agr.

Michigan and Illinois, in which States it has done considerable injury. The psyllas are nearly related to the plant-lice and are sometimes called jumping plant-lice, on account of the habit of the adults of giving a quick jump and flying from the foliage when disturbed. Like the plant-lice they reproduce very rapidly and suck the juices from the foliage and fruit. Usually the first indication of the pest is the presence of large quantities of honey-dew, secreted by the nymphs, with which the foliage becomes covered, and which attracts numerous ants. When the psyllas are numerous the leaves and fruit become coated with this sticky

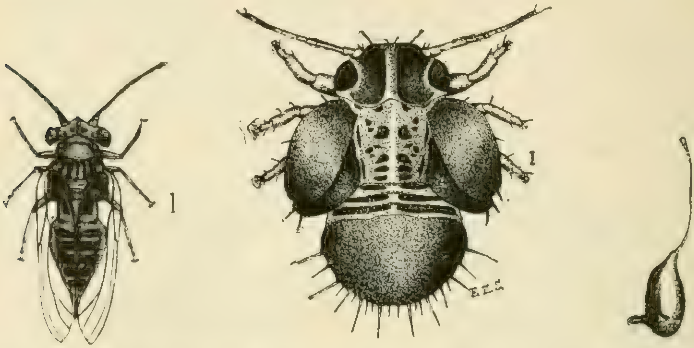


FIG. 495.—The pear psylla (*Psylla pyricola* Foerst): adult, full-grown nymph and egg—all greatly enlarged in different proportions. (After Slingerland.)

substance and it even drops from them like rain and runs down the trunk. A blackish fungus grows on the honey-dew and is always a good indication of the presence of the psylla.

Badly infested trees are so injured by loss of sap that they shed their leaves in midsummer, the lower ones being the first to turn yellow and drop. The young fruit also drop from badly infested trees, which make but little growth, as the young shoots are often attacked and wither early in the season.

The adult psylla is about one-tenth inch long, of a reddish-crimson color with brownish-black markings, bronzy eyes and dark wing-veins, looking very much like a miniature cicada or dog-day harvest-fly.

Life History.—The adults hibernate over winter in crevices of the bark and there lay their eggs late in April or early May on the twigs or around the buds. The egg is about one-eighteenth inch long, hardly perceptible without a lens, and orange-yellow in color. It is pear-shaped with the small end drawn out into a long thread, and the larger end is attached to the bark by a short stalk (Fig. 495). The later generations deposit the eggs on the leaves often in rows or bunches. The eggs hatch in two to three weeks and the young nymphs feed on the leaf petioles in the axils of the leaves and later on the leaves, young fruit and tender shoots, from which they suck the sap. The nymph is a peculiar-looking little bug, broadly oval, flattened, of a yellowish color, with crimson eyes, but later becomes reddish with black markings and conspicuous black wing-pads, as shown in Fig. 495. They move very slowly and are frequently quite covered by their own honey-dew. After molting some four or five times, they finally transform to adults in about a month. According to Slingerland there are four generations in New York and probably five in Maryland.

Control.—As the adults hibernate over winter in the bark the treatment advised for the pear leaf blister-mite furnishes the best means of control for the psylla, and winter treatment is absolutely essential for its successful control. Otherwise, the best time to spray is in the spring just after the eggs have hatched and before the nymphs have secreted much honey-dew. If winter or spring spraying has been neglected, the trees should be thoroughly sprayed with whale-oil soap, 1 pound to 4 gallons, or 10 per cent kerosene emulsion, or dilute miscible oils. Spraying should be done after a shower, which will wash much of the honey-dew off, as the chief difficulty in summer spraying is to reach the nymphs through the thick coating of honey-dew with which they are covered. Obviously the spray should be applied with considerable pressure in a coarse spray.

The Pear Slug *

Not infrequently the foliage of pear and cherry, and occasionally of plum, trees turns brown in midsummer, which is found to be due to small, slimy, slug-like larvæ which have eaten off the surfaces of the leaves. The Pear Slug is a common pest throughout the country, having been known here for over a century. It is an old European pest and has become distributed to many of the

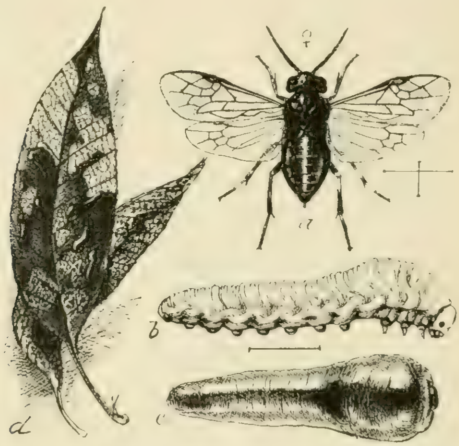


FIG. 196.—The pear slug (*Eriocampoides limacina* Retz.): *a*, adult female saw-fly; *b*, larva with slime removed; *c*, same in normal state; *d*, leaves with larvæ—natural size; *a*, *b*, *c*, much enlarged. (After Marlatt, U. S. Dept. Agr.)

British colonies in various parts of the world. The parent insect is a small saw-fly, about one-fifth inch long, glossy black, with four wings which are iridescent, with a smoky band across the middle, and which are folded over the back when at rest.

Life History.—The flies are abroad by the time the foliage is well out, by the middle of April in Maryland and late May or early June in New England. Like most of the saw-flies the female is furnished with a strong ovipositor with saw-like teeth at the

* *Eriocampoides limacina* Retzius. Family *Tenthredinidæ*. See C. L. Marlatt, Circular 26, Div. Ent., U. S. Dept. Agr.

tip, with which she cuts a little blister-like cell beneath the upper surface of the leaf, in which the egg is deposited, as shown in Fig. 497. The egg hatches in about two weeks and the little larva makes its way out of the cell through a crescent-shaped cut.

The young larva is at first nearly white, except the yellowish-brown head, but very soon a slimy or gluey olive-colored liquid exudes from over the entire body, giving it the appearance of a minute slug, from which it gets its name. The head is now dark brown, appearing almost black under the slime, and the body is also darker. The anterior segments are much swollen, concealing the head and the thoracic legs. The abdomen is furnished with

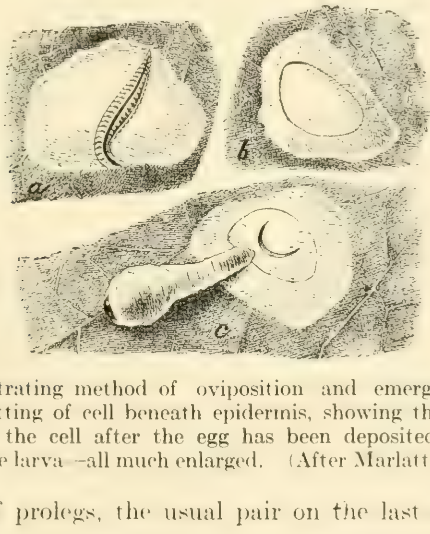


FIG. 497.—Illustrating method of oviposition and emergence of the pear slug: *a*, cutting of cell beneath epidermis, showing the tip of the ovipositor; *b*, the cell after the egg has been deposited; *c*, same after escape of the larva—all much enlarged. (After Marlatt U.S. Dept. Agr.)

seven pairs of prolegs, the usual pair on the last segment being wanting so that the tip of the abdomen is slightly elevated. The little slugs commence eating out small bits of the upper surface of the leaf, which they gradually enlarge until nearly the whole upper surface is denuded, leaving merely a network of veins, held together by the brown epidermis of the lower surface, which is nearly intact. Leaves thus injured turn brown, die and drop, so that a tree will sometimes be nearly defoliated, except for the new growth which starts out. The larvæ grow rapidly, becoming full grown in about twenty-five days, when they are about one-

half inch long. When full grown the larva molts for the fifth time and loses its olive-green slimy appearance, becoming a light orange-yellow color, clean and dry, with a light-colored head marked by only the small circular black eye-spots on the sides.

The larva now enters the ground for an inch or two, where it forms a small cell, which is moistened with saliva so that the walls become somewhat impervious to water. In six or eight days it transforms to the pupa and in about two weeks after the larva entered the ground the adult fly digs its way out of the soil. Some of the larvæ of each generation, and all of those of the last generation remain in the soil over winter and transform to pupæ the next spring. At Washington, D. C., the first generation of larvæ disappear by the end of June and the second generation are most abundant in early July, when the principal injury is done, which is probably followed by a third generation. Further north there are but two generations, the second appearing in August.

Control.—By spraying with any of the arsenicals when the work of the slugs is first noticed on the foliage they may be quickly destroyed. Whale-oil soap, or other soap, 1 pound to 4 gallons, will also destroy the larvæ as a contact insecticide. Hellebore, air-slaked lime, or almost any finely divided dust, thoroughly dusted over the trees will also destroy most of the larvæ, which are very readily killed. In gardens where water under pressure is available, the slugs may be washed off by a jet from a hose, as they are frequently washed off by heavy rains, and are much less injurious in wet seasons.

CHAPTER XXVIII

INSECTS INJURIOUS TO THE PEACH, PLUM, CHERRY AND STONE FRUITS *

The Peach Borer †

WHEREVER peaches are grown they are subject to the attacks of the ever-present borers, and if neglected will soon succumb to their injury. East of the Rocky Mountains the common peach-tree borer has been known since the earliest settlements, and it also occurs in Colorado and Oregon. It is a native insect which probably lived on wild cherry and wild plum, and is known to attack plum, prune, apricot and nectarine, though chiefly a peach pest. On the Pacific Coast a nearly related species, the California peach-tree borer,‡ does similar injury and has very similar habits. The lesser peach borer § is commonly associated with the common peach borer and has done considerable injury in western New York, Maryland, Virginia and Georgia. It occurs throughout the country and is doubtless commonly confused with the larger and more common species. Although it is quite different in its life history and habits, the injury is very similar, and as it must be controlled by the same methods it need not be separately considered.

The presence of the borers may be detected by the mass of gummy, gelatinous material, more or less mixed with soil, which

* See J. B. Smith, Bulletin 235, N. J. Agr. Exp. Sta.

† *Sanninoidea exitiosa* Say. Family *Sesiidæ*. See Quaintance, Yearbook U. S. Dept. Agr., 1905, p. 330; M. V. Slingerland, Bulletin 176, Cornell Univ. Agr. Exp. Sta.; H. N. Starnes, Bulletin 73, Geo. Agr. Exp. Sta.

‡ *Sanninoidea opalescens* Hy. Ed. See C. W. Woodworth, Bulletin 143, Cal. Agr. Exp. Sta.

§ *Synanthedon pictipes* G. & R. See A. A. Girault, Bulletin 68, Part IV, Bureau of Entomology, U. S. Dept. Agr.

exudes from the crowns of trees injured by them. The injury is done by the larvæ feeding on the soft inner bark of the crown of the root, the adjacent roots and the base of the trunk. Often the larvæ will completely girdle a tree and where a tree is infested by several borers, the foliage turns yellow and if not treated will soon die. Such a tree is much more susceptible to the attacks of bark beetles and diseases. Probably as many peach trees

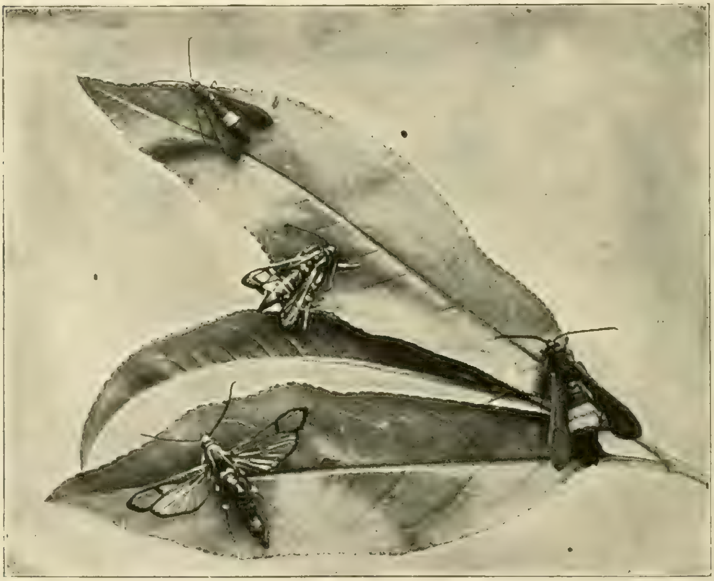


FIG. 198.—Peach borer moths (*Sanninoidea exitiosa* Say)—natural size. The upper one and the one at right are females, the other two males. (After Slingerland.)

are lost from the work of borers as from any other one pest, with the possible exception of the San José scale.

The adults are clear-winged moths which fly during the day and might be readily mistaken for wasps. The females are a deep steel-blue with a broad orange band across the abdomen. The fore-wings are opaque, covered by the bluish scales, and expand about 1¼ inches, while the hind-wings are transparent except the dark margin. The males are smaller, with the wings

clear except the margins and a line across the fore-wings, and the abdomen is marked with three or four narrow yellow stripes.

Life History.—The moths emerge in New York and New Jersey from the middle of July to the latter part of August, at Washington, D. C. from the middle of June until mid-September, the majority emerging in late July, while in Georgia the majority emerge in late August and early September. As there is but one generation a year, the time of emergence in these different latitudes is decidedly anomalous when compared with the life histories of other insects. The females soon lay their eggs, preferring to place them on the base of the trunk, but often placing them higher, or even on weeds or trash, or on the soil. A single female may lay from 200 to 800 eggs. The eggs are about one-fiftieth inch long, and slightly over half as wide, truncate at one end, and a light chestnut brown or reddish-brown in color, not easily seen on the bark of the tree. They hatch in about ten days and the young larvæ at once seek out small cracks in the bark through which they enter the soft bark of the tree. Their presence may be easily detected by the powdery, brownish frass which they throw out of their burrows. The young larvæ grow rapidly and continue feeding until forced into hibernation by cold weather, and in the South doubtless feed during warm days in the winter. Feeding is resumed in the spring, the larvæ boring through the lower layers of the bark and causing masses of gum to exude as already described. Larvæ of almost all sizes may usually be found in late spring, and the resulting moths appear irregularly over

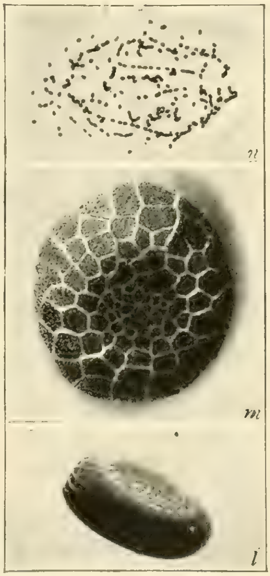


FIG. 499. — Eggs of the peach borer: natural size at *n*; an egg greatly enlarged at *l*; and end of egg greatly magnified, showing micropyle at *m*. (After Slingerland.)

a period of two to three months. It seems probable that some of the larvæ which hatch from eggs in late summer or early fall, do not become moths until the second subsequent season, so that they live in parts of three years, though the life cycle may occupy two years. The full-grown borer is a light yellowish larva about 1 inch long, with a brown head and thoracic legs, and five pairs of prolegs on the abdomen. The body is sparsely clothed with brownish hairs which arise from small, smooth tubercles. The grown larva constructs a cocoon at or near the surface of the ground, usually on the trunk near the

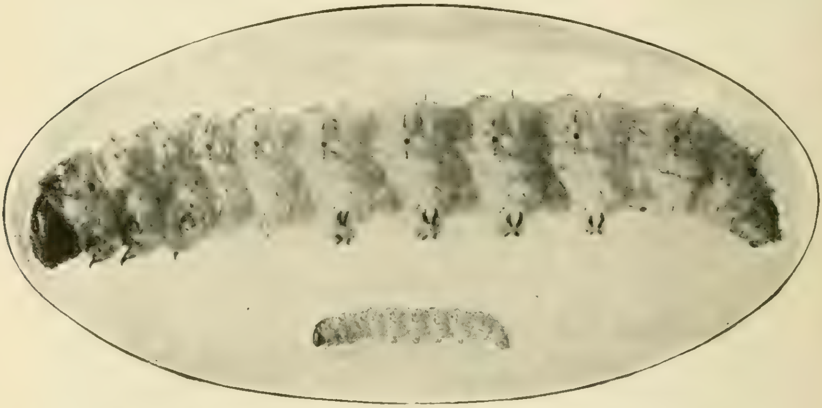


Fig. 500.—The peach borer larva, natural size and enlarged. (After Slingerland.)

burrow, but often on the soil, which is composed of particles of excrement and bark, bound together with gum and a thin lining of silk. In this it transforms to a brown pupa from which the moth emerges in about three weeks.

Control.—One of the best means of preventing injury and making the removal of the borers easier is to mound the soil around the trunk as high as possible, just before the moths emerge in the summer. This forces them to lay their eggs high up on the trunk, where the little borers may later be readily found. In some way this mounding seems to prevent the establishment of the young larvæ, as several experimenters have found that from half

to three-fourths of the borers are kept out of the trees in this way. In the early fall the earth should be leveled down to facilitate finding the little larvæ. Oviposition on the lower trunk may also be prevented by wrapping the trunk with building paper, or any heavy paper, which should extend well into the soil below and be tied tightly just below the crotch at the top. Such wrapping may be used to advantage with the mounding up of the earth and thus largely prevent oviposition. The wrappers should be applied before the moths appear and be removed in the early fall. Various washes composed of soaps, lime, glue, cement, carbolic acid, and various other ingredients have been commonly recommended and widely used for preventing the laying of the eggs and the entrance of the young larvæ, but careful tests have failed to show their value. Doubtless this is due to the roughness of the bark of the peach, over which it is difficult to make a complete coating, and the little larvæ will enter through the smallest crevice. Some wash which would penetrate the burrows of the young larvæ and destroy them, as does the avenarius carbolineum with the bark beetles (p. 546), would seem to be the most promising line of treatment, and some of the washes which have been extensively used by practical growers should be critically

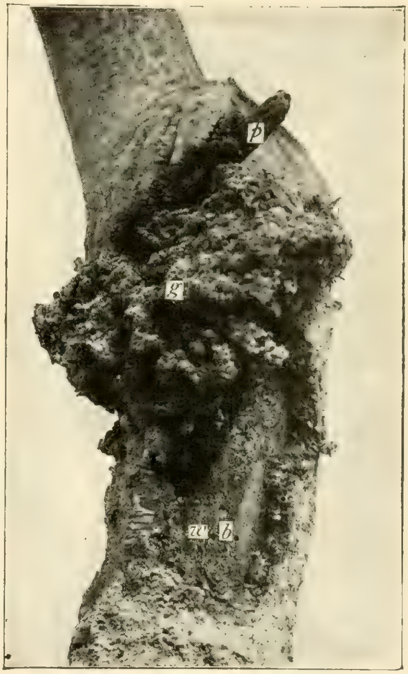


Fig. 501. — Work of a single peach borer, natural size: *w*, *b*, burrow of borer; *g*, gummy mass; *p*, pupa projecting from cocoon. (After Slingerland.)

tested on a commercial scale. After reducing the number of borers by mounding and wrapping the grower must resort to the old-fashioned method of "worming" the trees, by digging them out by hand. This should be done in the fall and again in late spring. Professor Starnes strongly recommends that in Georgia the chief dependence be placed upon the fall worming, as most of the young larvæ are then found upon the surface bark of the tree, more or less involved in a mass of gum and excreta, with which they may be readily scraped from the tree, according to his observations. For this work he recommends a small curved steel blade or hook about 4 or 5 inches long inserted in a wooden handle a foot in length. In the North fall worming seems to be less satisfactory. For spring work in excavating the larger worms, a sharp knife and a stout wire are commonly used, although many prefer a blacksmith's hoof-knife or similar tools which are specially constructed for the work.

The Peach Twig-borer *

On the Pacific Coast the Peach Twig-borer, often known there as the peach worm, is one of the most serious pests of the peach. In the Eastern States it has been injurious in Delaware, Virginia and Maryland, but only occasionally. Probably the insect occurs throughout the country wherever the peach is grown, as it is an old European insect which was first noticed in the United States in 1860. On the Pacific Coast the over-wintering larvæ bore into the tender shoots in early spring and during the summer bore into the fruit, particularly the later varieties. Prune, nectarine, apricot, almond, and pear are also injured.

The adult moth is a dark-gray color, with fore-wings expanding about one-half inch and marked with darker spots. The full grown larva is about one-half inch long, of a dull reddish-brown color with dark brown or blackish head.

Life History.—"The insect passes the winter as a very small

* *Anarsia lineatella* Zell. Family *Gelechiidæ*. See W. T. Clarke, Bulletin 144, Cal. Agr. Exp. Sta.; C. L. Marlatt, Bulletin 10, n. s., Div. Ent., U. S. Dept. Agr.; A. L. Quaintance, Yearbook U. S. Dept. Agr., 1905, p. 344.

larva in silken-lined cells or burrows in the spongy tissue of the bark at the crotches of the limbs. Their presence is indicated by small mounds of comminuted bark, as shown in Fig. 503, at *a* and *b*. Early in the spring, as the foliage is putting out, the larvæ begin to leave their burrows and attack the tender shoots, boring into and down the pith, the galleries ranging from about one-third inch to $1\frac{1}{2}$ inches in length. The shoot thus injured soon wilts and dies, as shown in Fig. 501, at *a*. Many shoots may be attacked by a single larva which is thus capable of doing considerable harm. There are two or three generations of larvæ during the summer in the West, those of the second and third attacking the fruit, the later varieties being the worst injured. According to Professor C. V. Piper, the larva enters the peach at the stem end, usually boring into the pit, the seed of which it seems to prefer, usually causing the stone to split as the fruit ripens; or simply the flesh may be tunnelled, depending on whether or not the stone is hard when the fruit is attacked. In California, according to Clarke, the larva usually enters the fruit along the suture at the stem end, and excavates a chamber beneath the skin, which blackens and shrivels somewhat, affording entrance to organisms of decay. In the ripe fruit the larvæ frequently make their way to and around the stone, which, if split, may be entered and the seed fed upon. . . . Early in the fall, about September 1, in California, the very young larvæ from eggs of the last generation of moths construct their hibernation cells in the soft tissue of the crotches of

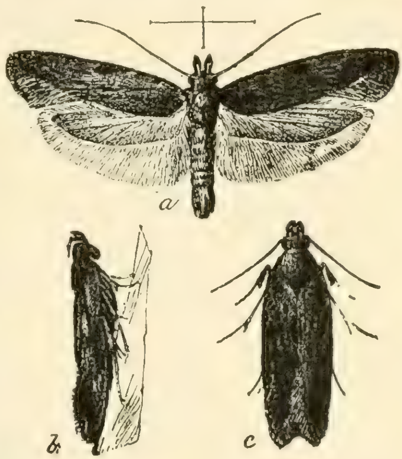


FIG. 502. — The peach twig-borer (*Anarsia lineatella*): adult moth with wings spread and folded — much enlarged. (After Marlatt, U. S. Dept. Agr.)

limbs, where they remain until the following spring, thus spending some six months in this condition."—Quaintance.

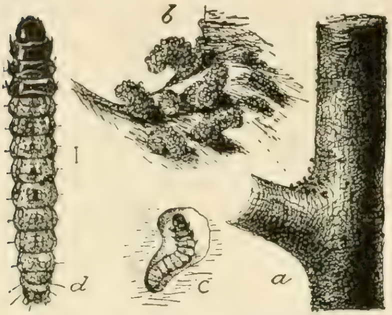


Fig. 503.—Peach twig-borer in winter quarters: *a*, twig, showing in crotch minute masses of chewed bark above larval chamber; *b*, same, much enlarged; *c*, larval cell enlarged; and *d*, larva very greatly enlarged. (After Marlatt, U. S. Dept. Agr.)

Control.—By spraying during the winter, or preferably after the buds have swollen in the spring with kerosene or distillate-oil emulsion, the oil is absorbed by the castings at the mouth of the burrows of the hibernating larvæ, and thus penetrates the burrows and kills the larvæ. Lime-sulfur wash, applied from the time the buds commence to swell until the first blossoms, has also been widely and successfully used. The wash should be applied as late as possible before blossoming. Recently Mr. E. P. Taylor has shown * that in western Colorado the larvæ are very readily killed by arsenate of lead, 3 to 5 pounds per barrel, applied just as the buds are beginning to open. The arsenate of lead must contain no soluble arsenic, or it may burn the foliage. This treatment is given at the same season as the lime-sulfur wash and is much easier to prepare and apply.

Fig. 504.— The peach twig-borer: *a*, new shoot of peach withering from attacks of larvæ; *b*, larva enlarged; *c*, pupa, enlarged. (After Marlatt, U. S. Dept. Agr.)

* E. P. Taylor, Bulletin 119, Colo. Agr. Exp. Sta., p. 8.

The Peach-tree Bark-beetle *

The peach-tree bark-beetle is very similar in both appearance and habits to the fruit-tree bark-beetle (consult p. 545), and may be readily confused with it. It is a native insect which attacks only peach, cherry and wild cherry, and so far has been injurious only in western New York, northern Ohio, and the Niagara district of Ontario, though it occurs from New Hampshire to North Carolina and west to Michigan.

"When the beetles are present in large numbers their injury to the tree is quickly brought to the attention of the orchardist by the large amount of sap exuding from the trees through the many small borings made both in the trunk and limbs of the tree. . . . The adults or beetles produce the primary injury to healthy trees, the work of the larvæ being secondary. The healthy trees, by repeated attacks of the adults, are reduced to a condition favorable to the formation of egg-burrows. When the beetles are ready to hibernate in the fall they fly to the healthy trees and form their hibernation cells. These latter are injurious to the trees, for through each cell there will be a tiny flow of sap during the following season." When the beetles emerge in the spring they bore into the bark of healthy trees and later leave them to form egg burrows in sickly trees. From these numerous burrows the sap issues in large quantities and in many cases forms large gummy masses around the trees. After three or four years of such injury the tree is so weakened that the beetles form their egg borrows beneath the bark and the larvæ soon finish its destruction. There are two generations a year, the summer brood appearing in the last half of August and the other hibernating over winter.

Control.—The same methods are advised as for the fruit-tree bark-beetle, which see (p. 546).

* *Phlœotribus liminaris* Harris. Family *Scolytidæ*. See H. F. Wilson, Bulletin 68, Part IX, Bureau of Entomology, U. S. Dept. Agr.

The Peach Lecanium *

The presence of the "terrapin scale," as this species is often called, is usually indicated by the sooty appearance of the branches and foliage of affected trees. This is due to the fact that the scales excrete considerable honey-dew, which covers the bark and leaves, and on which a sooty fungus propagates. It is a common species throughout the eastern United States and also attacks the apple, maple, sycamore, linden and birch, but is most injurious to peach and plum. The hibernating, partly grown, female scale

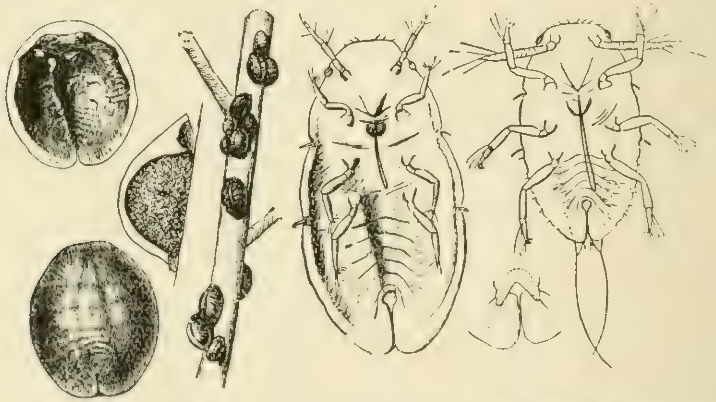


Fig. 505.—The peach lecanium or terrapin scale (*Eulecanium nigrofasciatum* Pergande): adults at left, natural size and much enlarged; young at right, and unfertilized female at center—much enlarged. (After Howard, U. S. Dept. Agr.)

found on the bark in winter, is about one-twelfth inch long, hemispherical, and of a reddish color mottled with radiating streaks of black, particularly about the margin. Sometimes these streaks coalesce and form a dark band around the center, while other individuals are occasionally entirely red or black.

Frequently trees become badly encrusted with these scales, but rarely are they killed by them. The fruit on badly infested

* *Eulecanium nigrofasciatum* Pergande. Family *Coccidæ*. See J. G. Sanders, Circular 88, Bureau of Entomology, U. S. Dept. Agr.; A. L. Quaintance, Yearbook U. S. Dept. Agr., 1905, p. 340; T. B. Symons and E. N. Cory, Bulletin 149, Md. Agr. Exp. Sta.

trees is, however, poorly developed, insipid, and covered with the sooty fungus so as to be almost unsaleable, and the trees are stunted and rendered more liable to the attack of other insects.

Life History.—There is but one generation a year. In the winter they are mostly nearly grown female scales. These mature early in the spring and deposit their eggs in a mass beneath the body, which forms the hard scale above them. In Missouri the eggs hatch about June 10th, and continue to hatch for a month. The male scales are much smaller than the females, elongate, slightly convex, and greenish-white in color. Late in July the winged males appear and live about a week. The young female scales continue growth during the summer and hibernate when about two-thirds grown.

Control.—Lime-sulfur wash is entirely ineffective against this species. Kerosene emulsion of 20 or 25 per cent, applied during the dormant season will destroy the hibernating females, according to Sanders. Spraying with kerosene emulsion 15 per cent, or whale-oil soap, 1 pound to 4 or 5 gallons of water, just as the eggs are hatching, is possibly the best treatment. As the eggs hatch for the period of a month, a second application may prove advisable.

The Black Peach-aphis *

The black peach-aphis is a native species which has been most injurious in the Middle Atlantic States, but has become widely distributed on nursery trees. It attacks the roots, tender shoots and foliage of the peach. When occurring on the roots, trees are often seriously injured before its presence is suspected. Young trees are particularly affected, the injured trees having a yellowish sickly foliage. Usually, however, the presence of the aphides on the young shoots and leaves will be an indication of its inhabiting the roots also. In the spring and early summer the aphides cluster on the tender shoots at the crotch of the tree and low

* *Aphis persicæ-niger* Er. Sm. Family *Aphididæ*. See C. P. Gillette, Bulletin 133, Colo. Agr. Exp. Sta., p. 37; A. L. Quaintance, Journal of Economic Entomology, Vol. I, p. 308. Yearbook U. S. Dept. Agr., 1905, p. 342.

down on the limbs and soon form a disgusting black mass over the young leaves, which are tightly curled up from the injury. On young trees in the nursery and on young orchard trees, this injury to the foliage is sometimes so severe as to kill or severely check the growth.

Both winged and wingless aphides are found on the foliage, but only the wingless forms occur on the roots. Both forms are about one-twelfth inch long and shining deep brown or black in color when mature. The partly grown aphides, which form the larger part of most colonies, are reddish-yellow or amber colored.

FIG. 506.—The black peach-aphis (*Aphis persicæ-niger* Er. Sm.): winged viviparous female; young female, first instar; apterous viviparous female—much enlarged. (After Gillette and Taylor.)

Life History.—The wingless aphides feed and reproduce upon the roots throughout the year, all being females and giving birth to live young after the manner of the aphides. In the spring some of them migrate to the young foliage, often appearing on the tender twigs before the buds open. They multiply rapidly, and as a result of the hundreds of little beaks sucking out the juices the shoot soon withers, which causes the young to develop into winged aphides which migrate to other trees. Honey-dew is excreted very freely by the aphides, which are therefore attended by numerous ants which doubtless aid in their transportation

from tree to tree and from the roots to the leaves and back. "During summer the aphides for the most part are to be found on the roots, though a few may be found on the foliage and the shoots in badly infested orchards at almost any time during the growing season. Below ground they occur promiscuously on roots of all sizes, but the smaller and more tender ones are preferred. Some of the aphides may retain their hold on the roots after the trees are dug, and the insect is thus frequently distributed on nursery stock. . . . Light sandy soils are worst infested, though they have been found in abundance on stiff clay soils." (Quaintance, l.c.). Neither the true sexual forms nor the eggs of this species have ever been observed, and there is room for a much better knowledge of its life history. It is stated by some writers that the aphides migrate to the roots in the fall.

Control.—The roots of young trees suspected of being affected should be carefully examined and if aphides are found they should be dipped in strong tobacco water. Nurserymen prevent injury by making liberal applications of tobacco dust in the trench and along the rows. Tobacco dust may also be used against the aphides on the roots of orchard trees by removing the surface soil and applying a liberal dressing of the dust, which will be leached down on to the roots by the rains. It should be applied over the smaller roots. The treatment for the root forms has not been sufficiently studied to warrant any conclusions as to satisfactory methods, but the same as advised for the woolly apple-aphis (p. 587) are suggested. When the aphides appear on the young shoots in the spring they may be readily controlled if the trees are observed for their appearance, for they are very gregarious, clustering on one shoot until it is well covered before spreading to the rest of a tree, and becoming abundant on it before spreading to others. Often the small infested shoots may simply be broken off and destroyed. The aphides may be killed by spraying them with kerosene emulsion, 15 per cent kerosene, tobacco extracts or whale-oil soap, 1 pound to 4 gallons. The spray should be applied with force so as to penetrate the honey-

dew and curled leaves, and should be applied early, as after the leaves are much curled it is difficult to reach the aphides.

The Green Peach-aphis †

This aphid is a European species which has long been known as a pest of peach foliage in this country, where it has become widely distributed. Considerable interest attaches to the species, as it furnishes a striking example of the summer migration of aphides to different food-plants, and a consequent difference in appearance in form and color. During the summer this species feeds upon various vegetables and succulent plants, and is so different in color and form that it has been well known not only as a separate species, but as belonging to a distinct genus. Concerning its injury to the peach, E. P. Taylor states: "The peach-growers of Western Colorado have suffered loss from it, from its heavy infestation of the leaves of the trees in the spring, causing them to curl and drop prematurely to the ground, and from the withering and subsequent dropping of the buds and forming peaches also infested by the aphides at this time." Similar injury has been reported from Missouri, and doubtless occurs occasionally in other sections.

Life History.—The winter is usually passed in the egg stage on the peach, plum, apricot, nectarine, cherry or other trees, though the wingless females sometimes persist on the summer food-plants where there is sufficient protection to enable them to endure the cold of winter, as in cabbage pits, or in the South. The small, oval, shining black eggs are deposited in the axils of the buds or in crevices of the bark. "The eggs hatch very early in the spring so that the young stem-mothers from them are often almost fully grown before the earliest peach or plum blossoms open. About the time the buds begin to open on these trees, the stem-mothers are all of a deep pink color and begin to

* *Myzus persicæ* Sulz. Family *Aphididæ*. (Syn.—*Rhopalosiphum dianthi* Schr.) See Gillette and Taylor, Bulletin 133, Colo. Agr. Exp. Sta., p. 32; C. P. Gillette, Journal of Economic Entomology, Vol. I, p. 359; E. P. Taylor, *ibid.*, p. 83; F. H. Chittenden, Bulletin 2, Va. Truck Exp. Sta., p. 30.

give birth to living young. These young instead of being pink like their mothers are pale yellowish-green throughout their lives, and usually there is a median and two lateral dark green stripes passing over the abdomen. Very few of this brood attain

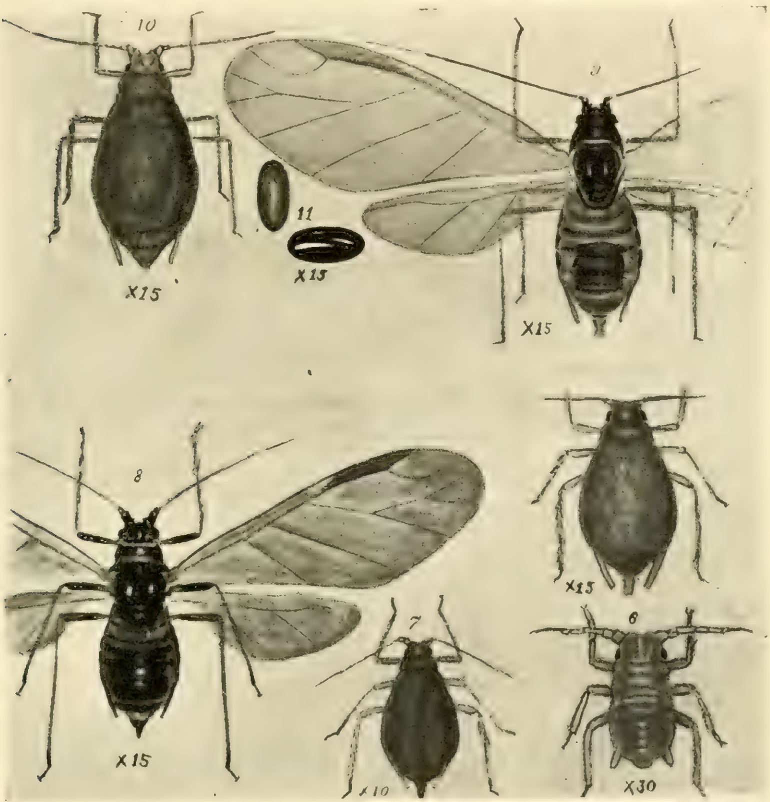


FIG. 507.—The green peach Aphis (*Myzus persicæ* Sulz.): 5, adult stem mother; 6, young of stem mother; 7, apterous viviparous female of second generation; 8, spring migrant; 9, fall migrant; 10, egg-laying female; 11, eggs—all much enlarged. (After Gillette and Taylor.)

wings. The third generation become very largely winged and begin leaving the trees upon which they were born about the middle of May in the peach-growing sections of the State (Colorado). By the middle of June these lice have almost completely left the

trees and may be found establishing their colonies upon various succulent vegetables," such as cabbage, turnip, rape, tomato, celery, and a long list of vegetables and flowers grown in greenhouses, where this species is a pest the year round. The list of food-plants is a long one, the largest of any species known to him, according to Professor C. P. Gillette, but it is a common and sometimes troublesome pest of cabbage (See p. 374) and celery and one of the most abundant of the various sorts of "green fly" of the greenhouse. The winged females which migrate from the peach are about one-twelfth inch long, with a wing expanse of one-third inch. They are a yellowish-green color with head, antennæ, thoracic lobes, honey-tubes, a large spot on the centre of the abdomen, and small lateral spots in front of the honey-tubes are blackish. The honey-tubes, or cornicles, are cylindrical, while those of the winged females in summer and fall are decidedly swollen toward the tip and constricted at the base, giving them a club shape, on account of which they were placed in the genus *Rhopalosiphum*. Otherwise the winged females of summer and fall are very similar, except that they are more yellowish and the markings and cornicles are lighter. The wingless females during the summer are pale yellowish and lack the longitudinal green stripes on the abdomen. According to Taylor's observations the spring generations on peach become full grown in about two weeks and an individual aphid lives about a month. As reproduction is probably more rapid in summer, the aphides may soon become very abundant. In the fall winged females return to the peach and winter host-plants, and give birth to young which develop into wingless females which lay the winter eggs. The true males are winged and migrate from the summer food-plants.

Control.—The trees affected should be sprayed about a week before the buds open with 5 to 7 per cent kerosene emulsion, tobacco extract, or whale-oil soap, 1 pound to 5 gallons, or miscible oil diluted 20 times. If the trees are sprayed with lime-sulfur for the twig-borer just before blossoming, it should kill most of the aphides. The same remedies may be used on the foliage of affected plants as necessary.

The Plum Gouger *

This is a native species which breeds upon wild plums and is most injurious to native varieties. It is common throughout the Mississippi Valley, but seems to be most injurious westward and occurs in Colorado. The work of the beetles might be easily mistaken for that of the curculio (p. 576). The adult beetle is readily distinguished from the curculio, however, by lacking the humps on the wing-covers. It is about one-quarter inch long, with a snout half as long, the wing-covers are a leaden-gray color, finely spotted with black and brown, while the thorax and head are marked with ochreous yellow.

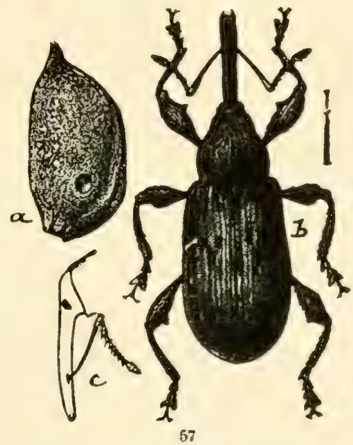


FIG. 508.—The plum gouger (*Coccotorus scutellaris* Lec.): *a*, plum stone showing exit hole of larva; *b*, adult; *c*, side view of head of beetle—enlarged. (After Riley and Howard, U. S. Dept. Agr.)

Life History. Like the curculio the beetles hibernate over winter and appear in the spring as the trees blossom. At first they puncture the calyx and feed on the ovary of the flower, completely destroying it for fruit production, and then puncture the growing plums, both for food and for egg-laying. In feeding on the plums the adults gouge out small round holes, from which gum exudes. Like the curculios, they have the habit of feigning death and dropping to the ground when disturbed. The eggs are laid while the pit of the plum is still soft. The female beetle drills a small hole in the plum, which is larger below, and in it deposits a small yellowish-white egg, whose outer end lies flush with the surface of the plum. As soon as the larva hatches it eats its way into the pit, feeding upon the meat of the seed until

* *Coccotorus scutellaris* Lec. Family *Curculionidæ.*

full grown. It then eats a hole through the outside of the pit so that the adult beetle may escape, and then transforms to a pupa. The larva is very similar to that of the curculio, but is a milky white rather than a glossy white and lacks the reddish tinge on the lower surface. Affected plums do not drop as when injured by the curculio. The pupal stage is passed in the pit of the plum and the adult beetle emerges through the hole cut for it by the larva. The beetles emerge a little before the plums ripen and often practically destroy them, as fruit badly punctured becomes gnarly and worthless. The beetles feed on the plums a short time and then seek hibernating quarters for the winter.

Control.—Jarring the trees as for the curculio is the only method of control which has been successfully used, but where the beetles are abundant it would be well to try spraying with arsenate of lead as advised for the curculio (p. 580).

Plum Aphides

Three species of aphides are common on the plum foliage in spring and fall, and often do serious damage by curling up the foliage in the spring and causing it to drop prematurely, thus checking the growth of the tree and preventing proper fruiting. The life histories of the three species are very similar in that the eggs are laid upon the plum in the fall, upon which two or three generations develop in the spring, but in early summer they migrate to other food-plants, from which they return to the plum in the fall. The life history is much the same as that of the apple-aphis (p. 658), and green peach-aphis (p. 597), and need not be rehearsed in detail.

The Mealy Plum-louse *

This is a light-green species which is covered by a bluish-white mealy powder. It has a long narrow body, one-tenth inch long,

* *Hyalopterus arundinis* Fab. Family *Aphididæ*. W. D. Hunter in Bulletin 60, Iowa Agr. Exp. Sta., p. 92, states that *Aphis prunifoliæ* Fitch is probably the same species. Certainly *H. arundinis* and *pruni*, *Aphis pruni* and *prunifoliæ*, seem to have been applied to the same species in the economic literature in America. See Lowe, V. L., Bulletin 139, N. Y. Agr. Exp. Sta., p. 657.

marked with three longitudinal stripes of a darker green. The honey-tubes are short, thick, and slightly constricted at the base.

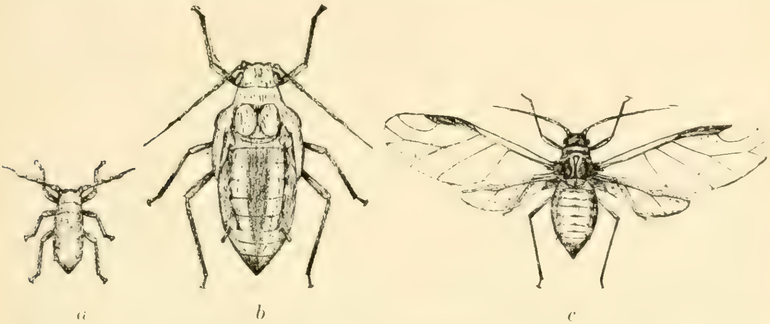


Fig. 509.—The mealy plum louse (*Hyalopterus arundinis* Fab.): *a*, young nymph; *b*, last stage of nymph of winged form; *c*, winged viviparous female—all much enlarged. (After Lowe.)

The winged female is similar in coloration except that the abdomen bears several transverse triangular marks of darker green. In

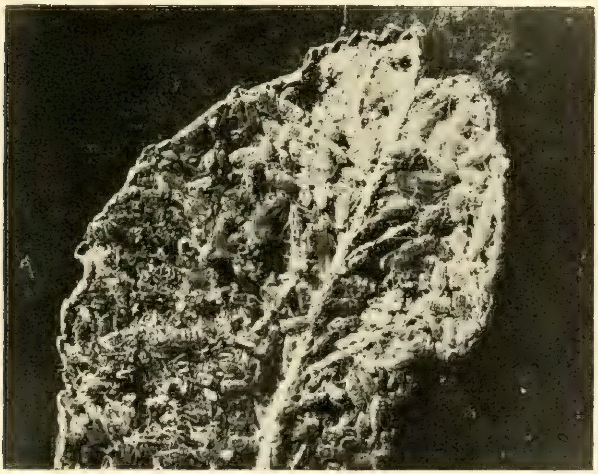


Fig. 510.—Mealy plum aphides clustered on leaf. (After Lowe.)

June the winged females migrate to certain grasses upon which the aphides reproduce during the summer, though small colonies are to be found on the plum throughout the summer. In the

fall they return to the plum, where the winter eggs are laid. This species is known to occur in Germany, England, Australia, and New Zealand, and seems to be widely distributed over the United States. It occurs here on plum and prune and in Europe is said to infest grape, peach, apricot, and nectarine, according to Lowe.

The Hop Plant-louse *

This species is best known as a pest of hops (see p. 275) during the summer and rarely does very serious damage to the plum, though often quite abundant on it. The wingless aphides are light green or yellowish green without any noticeable markings. The winged forms have the same body color, with the head, thoracic lobes, and a few dashes on the abdomen black. The species may be readily distinguished by the prominent tubercle which projects from the head on the inside of the base of each antenna, and a less prominent tubercle on the basal segment of each antenna, as shown in Fig. 204. According to the studies of Dr. C. V. Riley and his assistants, the third generation in the spring migrates from the plum to hops in late spring and in fall winged viviparous females give birth to a few young which develop into egg-laying females which mate with winged males which have developed on hops, the winter eggs being laid on the plum and other species of *Prunus*. In California Clarke has been unable to find any evidence of the species on plum or other vegetation outside of the hop yards, where he finds the true sexes occurring in the fall, but no evidence of eggs. Hops are often seriously damaged by being reduced in size and weight and from the loss in aroma due to the presence of the aphides in them. The species is of European origin, where it is a well-known enemy of hops, and has become widely distributed in the United States and Canada.

Control.—Where it oviposits on plum it may be best controlled by spraying as for the other plum aphides in the spring. After it becomes established on hops it may be controlled by

* *Phorodon humuli* Schrank. Family *Aphididæ*. See page 275 above. See C. V. Riley, Report U. S. Dept. Agr., 1888, p. 93; W. T. Clarke, Bulletin 160, Cal. Agr. Exp. Sta.

spraying with whale-oil soap, 1 pound to 6 gallons of water, or by the addition of quassia chips, which has long been the favorite remedy of hop-growers, 6 to 8 pounds of quassia chips are steeped in cold water for a day or two and then boiled for an hour, when they are mixed with 4 or 5 pounds of soft soap, whale-oil soap being excellent, and 100 gallons of water.

The Rusty-brown Plum-louse *

This species is readily distinguished from others common on plum and prune by the dark rusty-brown color, with the base of the antennæ, tibiæ, and tail a contrasting white. This species has become a very serious pest to plum foliage in the South and Southwest, and we have observed serious injury in New Hampshire, so that it is evidently widely distributed. The aphides collect on the tender young twigs, which they stunt or kill, assemble on the under sides of the leaves, which become corrugated and curled from their attack, and when abundant they attack the blossoms and their stems and thus prevent the setting of fruit. In early summer the winged females migrate to various common grasses, such as fox-tail, red top, barnyard grass, crab grass, and others, upon which they breed during the summer, and from which the winged forms return to plum in the fall. They become darker in color late in the season and the wingless, egg-laying female is almost black, as is also the small winged male.

Control.—The treatment advised for the apple-aphis (p. 658) will be effective for the three species above while on the plum, and for that and other species, the spraying should be done early in the season before the aphides have become numerous and curled the foliage.

* *Aphis setariæ* Thos. Family *Aphididæ*. See Gillette and Taylor, Bulletin 133, Colo. Agr. Exp. Sta., p. 41; C. E. Sanborn, Bulletin 88, Oklahoma Agr. Exp. Sta.

The Black Cherry-louse *

This species has long been known as a cherry pest in Europe and during the last fifty years has become generally distributed over the eastern United States, and occurs in Colorado. So far as known the cherry is the only food-plant. Dr. Weed was of the opinion that the aphides left the cherry during late July and migrated to some summer food-plant which he was unable to

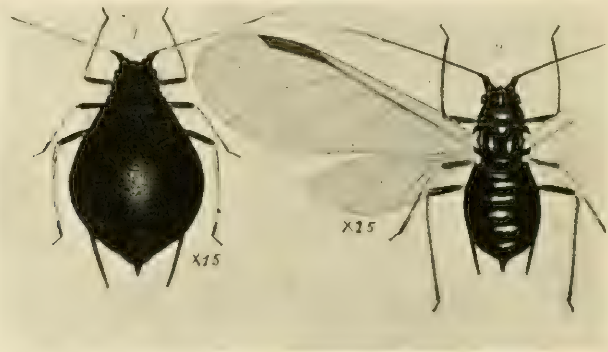


Fig. 511.—The black cherry-aphis (*Myzus cerasi* Fab.): 1, apterous viviparous female; 2, winged viviparous female—enlarged. (After Gillette and Taylor.)

find, but observations by Gillette and Taylor in Colorado would indicate that they may remain on the cherry, but become so reduced in numbers by their natural enemies that only a few survive during midsummer, and these give rise to larger colonies in late summer and early fall. Both the winged and wingless forms are deep shining black, the body is rather broad and flat, and the honey-tubes are unusually long and are cylindrical. Small winged males and wingless females occur on the foliage in the fall and the latter lay their eggs on the twigs about the buds. Like the black peach-aphis, this species has the habit of accumulating in large numbers on the smaller sprouts or limbs near the

* *Myzus cerasi* Fab. Family *Aphididæ*. See C. M. Weed, Bulletin Ohio Agr. Exp. Sta., Tech. Ser., Vol. I, No. 2, p. 111; C. P. Gillette, Journal of Economic Entomology, Vol. I, p. 362.

ground before spreading to the rest of the tree or other trees, so that prompt treatment when first observed will prevent general infestation.

Control.—Spraying with kerosene emulsion, whale-oil soap, tobacco extracts, or dilute miscible oils, as for the apple-aphis (p. 658), will control the pest.

The Cherry Fruit-fly †

The cherry fruit-fly is a native insect whose maggot lives in the flesh of the cherries, causing them to rot. It is very nearly related to the apple maggot (p. 632) which it very closely resembles

Fig. 512.—The cherry fruit-fly (*Rhagoletis cingulata* Loew.): *a*, fly: *b*, maggot; *c*, anterior spiracles of same; *d*, puparium; *e*, posterior spiracular plates of pupa—all enlarged. (After Chittenden, U. S. Dept. Agr.)

in both appearance and life history. Injury by it has been recorded in Massachusetts, New York, Ontario, Pennsylvania, District of Columbia, Michigan and Iowa, so that it is probably generally distributed over the northeastern States. Although its native food-plant is unknown it is probable that it lives on some wild sour cherry. As cherries are always more or less injured

† *Rhagoletis cingulata* Loew. Family *Trypetidæ*. See M. V. Slingerland, Bulletin 172, Cornell Univ. Agr. Exp. Sta.; F. H. Chittenden, Bulletin 44, Bureau of Entomology, U. S. Dept. Agr., p. 70.

by the plum curculio (p. 576), it is quite probable that injury by this maggot may have been attributed to the curculio and its identity passed unnoticed. Sour and subacid varieties, such as the Morello and Montmorency, are worst injured, but black cherries and indeed all varieties are more or less damaged.

The fly is slightly smaller than that of the apple-maggot, being about one-sixth inch long with a wing expanse of three-eighths inch. The body is blackish, the head and legs are pale yellowish-brown, the sides of the thorax are marked with a longitudinal

FIG. 513.—Section of a cherry, enlarged to show the maggot of the cherry fruit-fly and nature of its work. The small figures above show the maggot and parent fly natural size. (After Slingerland.)

yellow band, the abdominal segments are marked with whitish or pale brownish transverse bands, and the wings are crossed by four blackish bands. The maggot is about one-quarter inch long and is indistinguishable from the apple-maggot.

Life History.—The eggs are deposited just under the skin of the cherry from June until August, or probably during the whole season of the fruit. The eggs hatch in a few days and the little maggots penetrate to the pits, feeding on the flesh and forming a rotting cavity very similar to that made by the grub of the curculio. But few of the affected cherries fall from the trees.

and as they frequently show but little effect of the damage, the infested fruit may be marketed and the pest thus spread. When full grown the maggots leave the cherries and form puparia just beneath the surface of the ground, or in the bottom of baskets or in rubbish, wherever the affected fruit may be. The flies commence to emerge from these puparia by the middle of June in New York and are found during the summer months.

Control.—There is but little evidence as to practical means of control. Deep plowing in spring should result in burying the puparia so deeply as to prevent the emergence of the flies. Cultivation is evidently of little value, as the pest occurs in well-cultivated orchards, so that shallow cultivation does not seem to affect the puparia. Chickens have been observed to destroy the puparia, and will doubtless prove as effective as against the apple-maggot where they can be confined beneath affected trees on cultivated soil. The destruction of all fruit, whether windfall or remaining on the tree will, of course, aid in control. Recently a nearly related fruit-fly has been successfully controlled in South Africa by spraying the foliage with arsenate of lead sweetened with treacle or brown sugar, thus attracting the flies, which are poisoned by the arsenate, and this method is worthy of trial both for the cherry fruit-fly and apple-maggot.

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